

Title 7: Education K-12

Part 42: Agriculture Food and Natural Resources, Career Pathway

Science of Agricultural Plants

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The Research and Curriculum Unit, located in Starkville, MS, as part of Mississippi State University, was established to foster educational enhancements and innovations. In keeping with the land grant mission of Mississippi State University, the RCU is dedicated to improving the quality of life for Mississippians. The RCU enhances intellectual and professional development of Mississippi students and educators, while applying knowledge and educational research to the lives of the people of the state. The RCU works within the contexts of curriculum development and revision, research, assessment, professional development, and industrial training.

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Mr. Charles McClelland, Vice Chair
Ms. Kami Bumgarner
Mr. Howell “Hal” N. Gage
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Finally, standards in the *Science of Agricultural Environment Curriculum Framework and Supporting Materials* are based on the following:

National Agriculture, Food and Natural Resources (AFNR) Career Cluster Content Standards

The National AFNR Career Cluster Content Standards were developed by the National Council on Agricultural Education to serve as a guide for what students should know or be able to do through a study of agriculture in grades 9–12 and 2-year postsecondary programs. The standards were extensively researched and reviewed by leaders in the agricultural industry, secondary and postsecondary instructors, and university specialists. The standards consist of a pathway content standard for each of the eight career pathways. For each content standard, performance elements representing major topic areas with accompanying performance indicators were developed. Measurements of assessment of the performance elements and performance indicators were developed at the basic, intermediate, and advanced levels. A complete copy of the standards can be accessed at <https://aged.learn.com>. The National AFNR Career Cluster Content Standards are copyrighted to the National Council for Agricultural Education and are used by permission.

Applied Academic Credit Benchmarks

Mississippi Department of Education 2010 Mississippi Science Framework

21st Century Skills and Information and Communication Technologies Literacy Standards

In defining 21st century learning, the Partnership for 21st Century Skills has embraced five content and skill areas that represent the essential knowledge for the 21st century: global awareness; civic engagement; financial, economic, and business literacy; learning skills that encompass problem-solving, critical-thinking, and self-directional skills; and Information and Communication Technology (ICT) literacy.

National Educational Technology Standards for Students

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ACT College Readiness Standards



The College Readiness Standards are sets of statements intended to help students understand what is expected of them in preparation for the ACT. These standards are integrated into teaching and assessment strategies throughout the curriculum framework.

Preface

Secondary vocational–technical education programs in Mississippi are faced with many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing true learning activities to every student in the classroom. This accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, Mississippi Code of 1972, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, ch. 487, §14; Laws, 1991, ch. 423, §1; Laws, 1992, ch. 519, §4 eff. from and after July 1, 1992; Carl D. Perkins Vocational Education Act IV, 2007; and No Child Left Behind Act of 2001).

Research Synopsis

Agricultural and Environmental Science and Technology Research

The Agricultural Sciences Career Cluster covers the broad field of occupations related to the production and use of plants and animals for food, fiber, aesthetic, and environmental purposes. According to the U.S. Department of Labor, the growing interest in worldwide standardization of agricultural equipment should result in increased employment of agricultural engineers. Job opportunities should also result from the increasing demand for agricultural products, the continued efforts for more efficient agricultural production, and the increasing emphasis on the conservation of resources. The sales of food and fiber products amounted to 5.8 billion dollars in 2005 according to USDA statistics. Additionally, the Mississippi Department of Agriculture and Commerce estimates that 30% of the state’s workforce is employed in jobs relating directly or indirectly to agriculture.

Agriculture and Environmental Science and Technology will target careers at the professional and technical levels in agriculture. Students enrolled in these courses should be better prepared to pursue degrees at the community college and 4-year college levels.

Employment Projections

Data for this synopsis were compiled from employment projections prepared by the Mississippi Department of Employment Security and the U. S. Department of Labor. The National Agriculture, Food and Natural Resources (AFNR) Career Cluster Content Standards developed by the National Council for Agricultural Education and scholarly research articles were also reviewed as a guide for the redesign of the Agriculture and Natural Resources Cluster.

Industry Job Data – Employment Projections 2006 to 2016 for Mississippi

Note: Compiled by Mississippi Department of Employment Security and Labor Market Information Department

Occupational title	Employment, 2006	Projected employment, 2016	Change 2006–2016		Total Projected Avg. Annual Job Openings
			Number	Percent	
Animal Breeders	9,770	9,870	100	1.0	165
Agricultural and Food Science Technicians	260	310	50	19.2	10
Agricultural Equipment Operators	1,090	1,190	100	9.2	40
Agricultural Sciences Teachers, Postsecondary	190	240	50	26.3	20

Occupational title	Employment, 2006	Projected employment, 2016	Change 2006–2016		Total Projected Avg. Annual Job Openings
Conservation Scientists	790	890	100	12.7	30
Custodial and Caretaking Supervisors and Workers	46,920	54,110	7,190	15.3	2,320
Environmental Engineers	270	320	50	18.5	10
Environmental Engineering Technicians	50	100	50	100.0	0
Environmental Scientists and Specialists	420	470	50	11.9	10
Environmental Science and Protection Technicians	100	150	50	50.0	5
Farmworkers and Laborers, Crop, Nursery, and Greenhouse	5,160	5,810	650	12.6	225
Farmworkers, Farm and Ranch Animals	1,400	1,550	150	10.7	65
First-Line Supervisors / Managers of Farming, Fishing, and Forestry Workers	1,390	1,540	150	10.8	40
Food Processing Workers	14,920	18,320	3,400	22.8	680
Foresters	470	520	50	10.6	20
Forest and Conservation Technicians	390	440	50	12.8	15
Forest and Conservation Workers	880	980	100	11.4	30
Grounds Maintenance Workers	10,310	11,810	1,500	14.5	375

Occupational title	Employment, 2006	Projected employment, 2016	Change 2006–2016		Total Projected Avg. Annual Job Openings
Logging Equipment Operators	3,910	4,210	300	7.7	100
Purchasing Agents and Buyers, Farm Products	80	130	50	62.5	5
Soil and Plant Scientists	430	480	50	11.6	10
Veterinarians	540	640	100	18.5	25
Veterinary Assistants and Laboratory Animal Caretakers	690	890	200	29.0	35
Veterinary Technologists and Technicians	440	540	100	22.7	15

Note: Data was retrieved from the Mississippi Department of Employment Security (2009).

Occupational Employment and Wage Estimates for Mississippi May 2006

Occupation	Employment, 2006	Avg. Hourly Wage	Average Annual Wage
Farmers and Ranchers	2,760	\$17.85	\$43,560.00
Farm Managers and Supervisors	2,640	\$23.23	\$48,360.00
Logging Equipment Operators	3,890	\$14.28	\$30,880.00
Landscaping Supervisors	2,990	\$17.93	\$40,240.00
Landscape Workers	8,560	\$10.22	\$23,010.00
Agricultural Scientists/Technicians	29,680	\$18.33	\$38,555.00

Note: Data was retrieved from the U.S. Bureau of Labor Statistics (2009).

Curriculum Content

In compiling the research for the Agricultural Sciences cluster, face-to-face and telephone interviews were conducted with representatives of agricultural employers and agricultural agencies. The following comments summarize the results of these interviews:

- While opportunities to enter farming on a full-scale commercial enterprise basis are limited, opportunities do exist and are expected to increase as current operators retire and begin to rent their land to companies and individuals. Opportunities are also expected to increase for consultants and technicians who support production enterprises by providing specialized services to producers.
- There was general agreement among all persons interviewed that all students need to better develop skills related to leadership, teamwork, communication, and work ethics, habits, and values. All respondents also indicated that a basic knowledge of economics, recordkeeping, budgeting, and business decision-making skills will be essential in today's "lean" environment.
- Opportunities for high school graduates in all fields of agriculture are limited to the basic entry-level positions. More abundant opportunities exist for students who have received advanced training at the community college or 4-year college.
- All respondents agreed that a common core of knowledge and skills existed across all three major pathways related to the following themes: leadership and personal development; principles of plant science and production; principles of soil science and air and water quality; principles of agricultural power, structures, and technology; and principles of economics and management. A sixth theme, principles of animal science and production, exists for students in the AEST and Agriculture and Natural Resources pathway.

- All respondents agreed that students in all three pathways should be exposed to the process by which agricultural products are grown, managed, harvested, processed, and marketed. As students study this process, they should be also exposed to the different careers that are involved in all segments of the industry.
- The role of federal and state agencies including the USDA, OSHA, FDA, EPA, and so forth should be discussed. Also, the role of agricultural organizations such as the Poultry Association, Nurseryman’s Association, and Farm Bureau needs to be investigated.

Results of the survey of employers and agricultural agency representatives show that there are six major themes or topics that apply to a majority of occupations in the agriculture and natural resources area. These themes and their respective pathways are listed below.

Theme	AEST	Ag and Nat. Resources	Horticulture/Landscape
Principles of Leadership, Personal Development, and Career Success	X	X	X
Principles of Plant Science and Production	X	X	X
Principles of Animal Science and Production	X	X	
Principles of Soil, Water, and Air Quality, Conservation, and Use	X	X	X
Principles of Agricultural Power, Structures, and Technological Systems	X	X	X
Principles of Management, Economics, and Marketing	X	X	X

Executive Summary

Program Description

Science of Agricultural Plants is an advanced level course for the Agricultural and Environmental Science and Technology Program. The course focuses on the development of skills and knowledge related to the production of plants for food, fiber, ornamental, and other purposes. Instruction is provided in the basic principles of plant science as well as cultural practices and the use of technology to efficiently and effectively meet consumer needs. Plant growing structures, plant classification, growth, propagation, culture, pests, harvesting, and marketing are included. The course carries 1 Carnegie unit of credit that may count as an elective credit for high school graduation. Students may also earn an additional ½ Carnegie unit by completing a successful supervised agricultural experience program.

Industry Certification

No national industry recognized certifications are known to exist at this time in the field of Agriscience. Competencies and suggested performance indicators in the *Science of Agricultural Plants* course have been correlated, however to the National Agriculture, Food and Natural Resources (AFNR) Career Cluster Content Standards, which have been reviewed and endorsed at the national level by the National Council on Agricultural Education.

Articulation

The following articulation plan is in place for the AEST Pathway.

High School Program	Community College Program	Community College Course
Agricultural & Environmental Science & Tech – Concepts (CIP: 01.9999)	Ag Business & Mgmt Tech(Program CIP: 01.0304 – Field Crops)	AGT 1111 - Survey of Agriculture
Agricultural & Environmental Science & Tech – Environments (CIP: 03.0104)	Ag Business & Mgmt Tech(CIP: 01.0304 – Field Crops)	AGT 1313 - Applied Principles of Plant Production
Agricultural & Environmental Science & Tech – Animals (CIP: 01.0901)	Ag Business & MgmtTech (CIP 01.0302) Agricultural Animal Husbandry/Production)	AGT 1214 - Applied Principles of Animal Production
Agricultural & Environmental Science & Tech – Plants (CIP: 01.1101)	Ag Business & Mgmt Tech(CIP: 01.0304 – Field Crops)	AGT 1313 - Applied Principles of Plant Production
Agricultural & Environmental Science & Tech – Agricultural Mechanization (CIP: 01.0201)	Ag Business & Mgmt Tech(Program CIP: 01.0304 – Field Crops)	AGT 2563 - Agricultural Machinery and Shop Management

Assessment

Students will be assessed using the AEST MS-CPAS2 test. All students will be tested on *Concepts of Agriscience* and the second course that they may take in their chosen path of study. The second course may be one of the following:

- Science of Agricultural Animals
- Science of Agricultural Environment
- Science of Agricultural Mechanization
- Science of Agricultural Plants

The MS-CPAS2 blueprint can be found at <http://info.rcu.msstate.edu/services/curriculum.asp>. If there are questions regarding assessment of this program, please contact the instructional design specialist at the Research and Curriculum Unit at 662.325.2510.

Student Prerequisites

Prior to enrolling in *Science of Agricultural Plants*, a student must have completed *Concepts of Agriscience*. *Science of Agricultural Plants* may be offered to students in grades 10–12. It is recommended that students enrolling in the course possess at least a C average in other science courses and a TABE reading score at the eighth grade level or higher.

Proposed Applied Academic Credit

The academic credit is still pending for this curriculum.

Licensure Requirements

A 992 endorsement is currently required to teach any course in the Agricultural and Environmental Science and Technology Program. In order to receive a 992 endorsement, applicants must do the following:

1. Hold a valid Mississippi Educator License with endorsement #301 – Vocational Agriculture Education Programs or #302 – Agriculture.
2. Possess a baccalaureate degree in an agricultural subject area.
3. Complete the 3 semester credit hour course devoted to the teaching of Agricultural and Environmental Science and Technology courses. The course, AIS 6113 - Methods of Teaching Agriscience, is currently offered by Mississippi State University.
4. Applicant must enroll immediately in the Vocational Instructor Preparation (VIP) or the Redesign Education Program (REP).
5. Applicant must complete the individualized Professional Development Plan (PDP) requirements of the VIP or REP prior to the expiration date of the 3-year vocational license.
6. Applicant must successfully complete an MDE-approved computer literacy certification exam.
7. Applicant must successfully complete a certification for an online learning workshop, module, or course that is approved by the MDE.

Note: If the applicant meets all requirements listed above, that applicant will be issued a (992) endorsement—a 5-year license. If the applicant does not meet **all** requirements, the applicant will be issued a 3-year endorsement (license), and all requirements stated above must be satisfied prior to the ending date of that license.

Professional Learning

The professional learning itinerary for the middle school or individual pathways can be found at <http://redesign.rcu.msstate.edu>. If you have specific questions about the content of each training session provided, please contact the Research and Curriculum Unit at 662.325.2510, and ask for the Professional Learning Specialist.

Course Outlines

Course Description: Science of Agricultural Plants is a course that develops competencies related to the production of plants for food, fiber, ornamental, and other purposes. It includes instruction in the basic principles of plant science as well as cultural practices and the use of technology to efficiently and effectively meet consumer needs. Plant growing structures, plant classification, growth, propagation, culture, pests, harvesting, and marketing are included.

Science of Agricultural Plants (One Carnegie Unit) - Course Code: 991003

Unit	Title	Hours
1	Introduction to Agricultural Plants*	10
2	Supervised Experience in Agriculture*	5
3	Plant Growth and Nutrition	15
4	Plant Classification and Physiology	15
5	Plant Reproduction and Propagation	20
6	Plant Growing Structures	10
7	Cultural and Harvesting Practices	15
8	Pest Management	10
9	Marketing in Plant Production	5
	Total Hours	105

* Note: These units are not tested by MS-CPAS2.

Using This Document

Unit Number and Title

Suggested Time on Task

An estimated number of clock hours of instruction that should be required to teach the competencies and objectives of the unit. A minimum of 140 hours of instruction is required for each Carnegie unit credit. The curriculum framework should account for approximately 75–80% of the time in the course.

Competencies and Suggested Objectives

A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students will be expected to receive instruction on all competencies. The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level.

Suggested Teaching Strategies

This section of each unit indicates research-based strategies that can be used to enable students to master each competency. Emphasis has been placed on strategies that reflect active learning methodologies. Teachers should feel free to modify or enhance these suggestions based on needs of their students and resources available in order to provide optimum learning experiences for their students.

Suggested Assessment Strategies

This section indicates research-based strategies that can be used to measure student mastery. Examples of suggested strategies could include rubrics, class participation, reflection, and journaling. Again, teachers should feel free to modify or enhance these suggested assessment strategies based on local needs and resources.

Integrated Academic Topics, 21st Century Skills and Information and Communication Technology Literacy Standards, ACT College Readiness Standards, and Technology Standards for Students

This section identifies related academic topics as required in the Subject Area Testing Program (SATP) in Algebra I, Biology I, English II, and U.S. History from 1877, which are integrated into the content of the unit. Research-based teaching strategies also incorporate ACT College Readiness standards. This section also identifies the 21st Century Skills and Information and Communication Technology Literacy skills. In addition, national technology standards for students associated with the competencies and suggested objectives for the unit are also identified.

References

A list of suggested references is provided for each unit. The list includes some of the primary instructional resources that may be used to teach the competencies and suggested objectives. Again, these resources are suggested, and the list may be modified or enhanced based on needs and abilities of students and on available resources.

Science of Agricultural Plants

Unit 1: Introduction to Agricultural Plants

10 Hours

Competency 1: Examine how plants are used to meet human and environmental needs. PS.01, BIO1, BIO 3, BO 4, BO5

Suggested Enduring Understandings

1. Plants are renewable resources that meet essential human needs by providing a wide variety of products that provide food, clothing, and shelter.
2. Plants contribute to the environment and quality of life by converting sunlight into useable forms of energy, by converting greenhouse gases such as carbon dioxide into oxygen and by protecting and improving the soil and water resources.
3. Proper sanitation and handling measures for plant products reduce the chances of foodborne illnesses being transmitted to consumers.

Suggested Essential Questions

1. How do plants contribute to meeting essential human needs?
2. How do plants contribute to the environment and quality of life on earth?
3. How does sanitation affect the safety of plant products?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Examine the importance of plants in meeting essential human needs for food, clothing, shelter, and energy. (DOK 2)	a. Have students read Chapter 1 from the text (Biondo & Lee, 2003). Have them brainstorm ways in which plants affect their daily lives and contribute to their well-being. Compare the use of plants in the United States to their uses in other countries. Have students keep a log of plant products that they come in contact with during the week and prepare a chart showing which parts of each species are used in the products. Students should use the <i>Plant Use in Daily Life Assignment (1.1)</i> . <small>CS 3, CS4, T6, R5</small>	a. Evaluate the plant contact log for accuracy and completeness.
b. Describe how plants contribute to the environment and quality of life. (DOK 1)	b. Lead a class discussion on how plants contribute to the enhancement of the environment in general through processes such as photosynthesis and transpiration and through protection of the soil and water supply. <small>CS3, CS4</small>	b. Evaluate student understanding through a paper and pencil test.

Competency 2: Examine plant production enterprises. PS.02, BO 4

Suggested Enduring Understandings

1. The production of field, foliage, and fiber

Suggested Essential Questions

1. What general skills and knowledge are

- plants requires knowledge of planting and cultural practices, production, sanitation, costs and returns, and marketing.
2. Ornamental and landscaping crops are grown as bedding plants, pot plants, foliage or flowering plants, container plants, and shrubs or trees.
 3. Trees provide a number of forest products that are used in manufacturing, construction, paper making, chemical, and food products industries.
2. What are the different types of plants grown for ornamental purposes?
 3. What products are produced from trees and forests?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
<p>a. Identify different field and forage crops used for food and fiber production, and explore their production practices. (DOK 1)</p>	<p>a. Assign each student complete a <i>Plant Production Fact Sheet (1.2)</i> on a specific field, forage, or fiber plant, and have them conduct research on that area. The fact sheet should include incorporating a picture of the crop, planting practices, cultural techniques, estimated costs and returns, and marketing practices. Grade and correct the fact sheet, and post to the class Blackboard site, or make copies and provide to all students for study. ^{CS} <small>1, CS2, CS4, T1, T2, T3, T4, T6, R1, R2, R5, W2, W4, W5</small></p>	<p>a. Evaluate student fact sheets for accuracy and completeness.</p>
<p>b. Relate the importance of sanitation to plant production, animal and human health, and Hazard Analysis and Critical Control Point (HACCP) programs. (DOK 2)</p>	<p>b. Introduce the competency by stating that it is estimated that foodborne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the United States each year. Known pathogens account for an estimated 14 million illnesses, 60,000 hospitalizations, and 1,800 deaths. Have students review the HACCP Manual for Chicago Schools. Assign students a section of the manual to read and summarize in a one-page fact sheet that applies to plant production and pest control in agriculture. Have students present their fact sheets and discuss the most important points. List major points on the LCD projector, and have students transcribe into their electronic notebooks or journals. ^{CS1, CS2, CS4, CS5}, T1, T2, T3, T4, T6,</p>	<p>b. Use the <i>HACCP Fact Sheet Rubric (1.7)</i> to evaluate student performance on this indicator.</p>

c. Identify and describe different types of ornamental and landscaping crops. (DOK 1)	c. Lead a classroom discussion on the different types of ornamental and landscaping crops (bedding plants, foliage plants, flowering plants, container plants, shrubs, trees, etc.). List important points concerning each type on the whiteboard or LCD projector, and have students enter these points into their electronic journals or notebooks. <small>CS3, T2, T3, T6, R4, R5, W4, W5</small>	c. Use a written test to evaluate student understanding on this indicator.
d. Explore the different types of forest products. (DOK 1)	d. Invite a representative of the forest industry to speak to the class on the variety of products that come from the forest (hardwood and softwood lumber, pulp, chips, veneer, chemicals, etc.). Follow up with a class discussion to make sure all major points are listed. Have students take notes and record major points in their electronic journals or notebooks. Follow up with a class discussion to make sure all major points are listed. <small>CS1, CS4, T6, W4, W5</small>	d. Evaluate student notebooks or journals for accuracy and completeness.

Competency 3: Demonstrate career and leadership skills required for employment in the plant industry.

Suggested Enduring Understandings

1. Most careers in the plant industry require knowledge of plant anatomy and physiology, planting and other cultural practices, as well as marketing, and management of plant enterprises.
2. In addition to technical skills in plant production, leadership, human relations, and general workplace skills are essential for success and advancement in a career.

Suggested Essential Questions

1. What different skill areas are needed for plant production careers?
2. What leadership, human relations, and general workplace skills are needed?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Identify and explore careers in the plant production industry including major skill areas required by employees. (DOK 2)	a. Provide a list of career areas in the plant industry. Have each student select an area of personal interest and prepare a PowerPoint presentation on the area. The presentation should include information on major skill areas, educational requirements, salary, specific skills, and occupational outlook. <small>CS2, CS4, T2, T3, T4, T6, R1, R2,</small>	a. Evaluate student PowerPoint for accuracy and completeness.

<p>b. Demonstrate leadership, human relations, and workplace skills. (DOK 2)</p>	<p>b. Provide students with the listing of <i>21st Century Life and Career Skills (1.3)</i> found in this unit. Lead students in a discussion of how these skills apply to their current career as students and will apply to their career success after school. Provide students with a copy of the rubric that will be used to evaluate each student's demonstration of life and career skills. Have students self-evaluate their current scores on this rubric and explain that they will be periodically (at least once a grading period) graded on their ability to demonstrate these skills. <small>CS1, CS2, CS3, CS4, CS5, T6</small></p>	<p>b. Use the <i>Rubric for Evaluating 21st Century Life and Career Skills (1.4)</i> to evaluate student attainment. This is an ongoing assessment throughout the year.</p>
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Competency 4: Demonstrate general safety precautions for the laboratory and greenhouse. BO 1, ES 1

Suggested Enduring Understandings

1. All workers must fully understand and comply with procedures for maintaining a safe and orderly workplace such as chemical safety, use of personal protective equipment, and general safety rules and policies.
2. Each person is responsible for promoting safety through his or her actions.
3. Each person must know the location of all safety devices, storage areas, exits, power controls, and environmental controls.
4. Each person must know and understand safety precautions for the handling, storage, use, and disposal of hazardous materials, including the location and contents of material safety data sheets.

Suggested Essential Questions

1. What am I expected to do in order to maintain a safe and orderly workplace?
2. What personal responsibilities and actions am I accountable for in the workplace?
3. What safety devices are present in the workplace and where are they located?
4. How are hazardous materials handled, stored, used, and disposed of?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
<p>a. Describe procedures for working in and maintaining a safe and orderly workplace. (DOK 1)</p>	<p>a. Provide students with a list of safety and housekeeping procedures that must be followed when working in the AEST laboratory and greenhouse (chemical safety, general laboratory safety, using glassware, personal protective equipment, laboratory rules and policies, etc.). Discuss these procedures with the students asking them to identify specific actions that either meet or do not meet the procedure. Have students sign an agreement</p>	<p>a. Assess student understanding through the use of a safety test. Students must answer 100% of all questions correctly.</p>

	stating that they have received and discussed procedures. <small>CS1, CS2, CS3, CS4, T5</small>	
b. Identify actions associated with safe personal behavior and conduct. (DOK 1)	b. Have students demonstrate and role-play acceptable and unacceptable behavior and conduct. Allow other students to view the role play and critique. <small>CS1, CS2, CS3, CS4, CS5, T1, T2, T3</small>	b. Use the <i>Rubric for Evaluating Role-Play on Behavior (1.5)</i> to evaluate student mastery.
c. Describe work site and laboratory organization procedures. (DOK 1)	c. Take students on a tour of the AEST lab and greenhouse, showing them the location of safety devices, emergency exits, storage facilities, tools and equipment, environmental controls, and so forth. During the tour, discuss procedures and policies related to the lab equipment and supplies. Demonstrate the use of safety devices and equipment. Identify potential hazards and safety procedures. <small>CS2, CS3, T6</small>	c. Assess student knowledge through the use of informal questioning following the tour. Follow up with a paper and pencil test.
d. Demonstrate procedures for safe use of chemicals and other hazardous materials in the laboratory and greenhouse, including the use of materials safety data sheets (MSDSs). (DOK 3)	d. Identify hazardous materials used in the AEST laboratory and greenhouse, and demonstrate their safe and proper storage, use, and disposal. Show students the location of the material safety data sheets (MSDSs) for hazardous materials. Provide students with a copy of a MSDS, and have the students read and complete the assignment <i>Interpret a Material Safety Data Sheet Worksheet (1.6)</i> to demonstrate their understanding. <small>CS2, CS4, CS5, T4, T6, R1, R2, R4, R5, S1</small>	d. Evaluate the student assignment for accuracy and completeness.

Standards

AFNR Industry Standards

- PS.01. Apply knowledge of plant classification, plant anatomy, and plant physiology to the production and management of plants.
- PS.02. Prepare and implement a plant management plan that addresses the influence of environmental factors, nutrients, and soil on plant growth.

Biology I

- BIOI 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BIOI 3 Investigate and evaluate the interaction between living organisms and their environment.

Botany

- BO 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BO 4 Draw conclusions about the factors that affect the adaptation and survival of plants.
- BO 5 Relate an understanding of plant genetics to its uses in modern living.

Environmental Science

- ES 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS3 Social & Cross-Cultural Skills
- CS4 Productivity & Accountability
- CS5 Leadership & Responsibility

National Education Technology Standards for Students (NETS)

- T1 Creativity and Innovation
- T2 Communication and Collaboration
- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T5 Digital Citizenship
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- R1 Main Ideas and Author's Approach
- R2 Supporting Details
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- S1 Interpretation of Data
- W4 Organizing Ideas
- W5 Using Language

Suggested References

- 3E Company. (n.d.). *MSDS Solutions Center*. Retrieved on June 14, 2010, from <http://msds.com>
- Barr Films. (2010) *Lab safety: The accident at Jefferson High* [video]. Retrieved June 14, 2010, from <http://www.ket.org/itvvideos/offering/science/labsafety.htm>
- Biondo, R. J., & Lee, J. S. (2003). *Introduction to plant and soil science technology* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Biondo, R. J., & Lee, J. S. (2002). *Introduction to plant and soil science technology activity manual* (2nd ed.). Lebanon, IN: Interstate Publishing.
- CEV Video. (n.d.). *CEV Pathway: Plant Systems Pathway* [DVD]. Lubbock, TX: Author.
- HACCP. (2007). *Hazard analysis critical control points*. Chico Unified School District. Nutritional Services Department. Retrieved on June 14, 2010, from http://www.cusd.chico.k12.ca.us/_dept/business/documents/CUSD_HACCP_PLAN.pdf
- National FFA Organization. (n.d.). *American degree handbook*. Retrieved on June 14, 2010, from http://www.ffa.org/documents/degree_handbook.pdf
- U. S. Department of Labor, Bureau of Labor Statistics. (n.d.). *Occupational outlook handbook (OOH)* (2010–11 ed.). Retrieved on June 9, 2010, from <http://www.bls.gov/OCO/>
- Greenhouse and nursery safety: Industry in action*. VEP. ISBN 1569181640
- For additional references, activities, and web resources, please refer to: Information and Computer Technology B.R.I.D.G.E. Web site: <http://www.rcu.blackboard.com> (Available only to registered users).

Science of Agricultural Plants

Unit 2: Experiential Learning (SAE)

5 Hours

Competency 1: Plan and implement an experiential learning program. ABS.02, ABS.04

Suggested Enduring Understandings

1. Planning is a continuous process in business.
2. Plans must be reviewed and updated on a regular basis.

Suggested Essential Questions

1. What are my goals and plans for an SAE in the coming year?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Update and revise long-range and short-term goals of the experiential learning program. (DOK 3)	a. Based on the summary and analysis of the students' previous experiential learning activities, have students reflect and revise or amend their experiential learning long-range and short-term goals for the coming year. The goals should be added to the students' electronic portfolios. <small>CS1, CS2, CS4, T1, T3, T4, T6, W1, W2, W4, W5</small>	a. Use an experiential learning planning rubric and record keeping rubric to evaluate the students' goals. (See the <i>Rubric for Experiential Learning Planning and Record Keeping (2.1).</i>)
b. Update, revise, and implement the experiential learning plan/training agreement for the coming year. (DOK 3)	b. Based on the revised goals, have students update, amend, and revise their experiential learning plan/training agreement to reflect growth in skill and proficiency levels. The updated plan should be added to the students' electronic portfolios. <small>CS1, CS2, CS4, T1, T3, T4, T6, W1, W2, W4, W5</small>	b. Use an experiential learning planning rubric and record keeping rubric to evaluate the students' goals. (See the <i>Rubric for Experiential Learning Planning and Record Keeping (2.1).</i>)

Competency 2: Maintain records and documentation of experiential learning activities, projects, and enterprises. ABS.02, ABS.03, ABS.04, ABS.06

Suggested Enduring Understandings

1. Records must be maintained and updated on a regular and timely basis to accurately reflect progress.
2. Records should be summarized to give a "snapshot" of operations on a regular basis that can be used to make decisions.

Suggested Essential Questions

1. How do I update and maintain the records of my experiential learning program?
2. How do I summarize and analyze my experiential learning records?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
<p>a. Update and maintain records of experiential learning related income, expenses, activities, skills, and supplementary improvement projects. (DOK 3)</p>	<p>a. Review requirements for record keeping for the different types of experiential learning. Have students maintain and update their records electronically throughout the year. <small>CS2, CS4, T3, T4, T6, M1, M2, W4</small></p>	<p>a. Use the <i>Rubric for Experiential Learning Planning and Record Keeping (2.1)</i> to evaluate the students' goals.</p>
<p>b. Prepare an annual summary report. (DOK 3)</p>	<p>b. Review procedures for summarizing records. Have students prepare an annual summary of their experiential learning activities at the end of the school year to include income and expense summary and a net worth statement. <small>CS2, CS4, T3, T4, T6, M1, M2, W4</small></p>	<p>b. Use the <i>Rubric for Experiential Learning Planning and Record Keeping (2.1)</i> to evaluate the students' summaries.</p>

Standards

AFNR Industry Standards

- ABS.02. Utilize appropriate management planning principles in AFNR business enterprises.
- ABS.03. Utilize record keeping to accomplish AFNR business objectives while complying with laws and regulations.
- ABS.04. Apply generally accepted accounting principles and skills to manage cash budgets, credit budgets, and credit for an AFNR business.
- ABS.05. Assess accomplishment of goals and objectives by an AFNR business.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS4 Productivity & Accountability

National Education Technology Standards for Students (NETS)

- T1 Creativity and Innovation
- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- M1 Basic Operations and Applications
- M2 Probability, Statistics, and Data Analysis
- W1 Expressing Judgments
- W2 Focusing on the Topic
- W4 Organizing Ideas
- W5 Using Language

Suggested References

- Cooper, E., & Burton, L. (2007). *Agriscience: Fundamentals and applications* (4th ed.). Clifton Park, NJ: Thomson Delmar.
- National FFA Organization. (n.d.). *Introduction to SAE* [PowerPoint presentation]. Retrieved June 9, 2010, from http://www.ffa.org/documents/sae_tch_intro.zip
- National FFA Organization. (2004). *Lesson 126: Taking my trip*. In *LifeKnowledge: Real lessons for real life* [CD-ROM software]. Indianapolis, IN: Author.
- National FFA Organization. (n.d.). *SAE best practices guide*. Retrieved June 9, 2010, from http://www.ffa.org/documents/sae_bp.pdf
- National FFA Organization. (2006). *SAE handbook* [CD-ROM edition]. Indianapolis, IN: Author.
- National FFA Organization. (2004). *SAE ideas*. Indianapolis, IN: Author.
- National FFA Organization. (n.d.). *Supervised agricultural experience*. Retrieved June 9, 2010, from http://www.ffa.org/index.cfm?method=c_programs.SAE
- Ohio Curriculum Materials Service. (n.d.). *Ohio electronic recordbooks*. Retrieved June 9, 2010, from <http://osu-cms.org/productdetails.cfm?PC=421>
- Texas Tech University. (n.d.). *Supervised agricultural experience*. Retrieved June 9, 2010, from <http://www.depts.ttu.edu/agriculturalteachers/Survival/AGTCHNBK/10SAE.PDF>

Science of Agricultural Plants

Unit 3: Plant Growth and Nutrition

15 Hours

Competency 1: Examine the principles of plant growth. PS.01, BIOI 1, BIOI 2, BIOI 4, BIOII 2, BO 1, BO 2

Suggested Enduring Understandings

1. People who work with plants are better able to do their jobs if they understand the basics of plant growth.
2. There are two types of cell division: meiosis (associated with sexual reproduction) and mitosis (associated with cell division).
3. Life processes of plants are regulated by hormones produced in the cells.

Suggested Essential Questions

1. How do plant cells reproduce?
2. Why do growers use plant growth retardants and stimulants?
3. What environmental factors cause plants to respond in certain ways?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Discuss the principles of cell division, including both mitosis and meiosis. (DOK 3)	a. Access prior knowledge on the subject matter using the <i>Pre-Knowledge Assessment Example (3.1)</i> . Use the Nova Online web site How Cells Divide, Mitosis and Meiosis to compare similarities and differences between mitosis and meiosis. Have students complete the <i>Onion Root Mitosis Activity (3.2)</i> . As an extra activity, have students perform the <i>Challenge Activity - Onion Root Tip Experiment (3.3)</i> . <small>CS1, CS2, CS4, T1, T2, T4, M5, R2, R3, R4, W2, W4</small>	a. Use the <i>Onion Root Mitosis Activity (3.2)</i> to evaluate student mastery.
b. Describe the use of growth retardants and stimulants. (DOK 1)	b. Have students search Web sites and prepare a newspaper article on plant growth retardants and stimulants to present to the class. (The instructor should suggest keywords to help students improve search strategies). <small>CS1, CS2, CS4, T1, T2, T3, T4, T6, R1, R2, R3, R4, R5, W2, W4, W5</small>	b. Use the <i>AgNews Rubric (3.5)</i> to evaluate the newspaper article.
c. List and explain the different types of tropisms. (DOK 1)	c. Have students use the <i>Tropism Summary and Demonstration Rubric</i> (Biondo & Lee, 2003, p. 51).	c. Evaluate students based on the <i>Tropism Summary and Demonstration Rubric (3.6)</i> .

Competency 2: Discuss basic principles of plant nutrition and soil pH. PS.02, BIOI 1, BIOI 2, BIOI 4, BIOII 2, BO 1, BO 2

Suggested Enduring Understandings

1. Essential nutritional elements are needed for plant growth.
2. If a plant does not receive the proper

Suggested Essential Questions

1. What is the difference between macronutrients and micronutrients?
2. What are some of the common

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| <p>nutrition, it will not grow or produce satisfactorily.</p> <p>3. Soil pH plays a large role in the availability of plant nutrients.</p> <p>4. When soil pH is above or below the plants preferred range, nutrients become unavailable, and plants do not grow or produce satisfactory.</p> | <p>symptoms of nutrient deficiencies in plants?</p> <p>3. What happens when too much fertilizer is applied?</p> <p>4. Why is soil sampling technique important?</p> <p>5. What range of soil pH are nutrients most available?</p> <p>6. How do growers adjust pH of soil?</p> |
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Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Differentiate between macronutrients and micronutrients. (DOK 3)	a. Project the periodic chart (http://www.chemicool.com/) on the board, and ask students if they remember what certain elements stood for. Show students a bag of fertilizer, and discuss label information. Write elemental symbols on board, and let students make up an analogy to help them remember from the text (Biondo & Lee, 2003, p. 94). Allow students to choose a plant nutrient to conduct Internet search on and develop a PowerPoint presentation that covers nutrient functions in the plant, excess and deficiencies symptoms, and pH influence. <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, R1, R2,R3, R4, R5, W4, W5</small>	a. Use the <i>Plant Nutrition PowerPoint Presentation Rubric (3.7)</i> to evaluate student mastery.
b. Describe the effect of excesses and deficiencies. (DOK 3)	b. Discuss effects of soluble salt buildup, remedies; show an example of soluble salt buildup at the bottom of a potted plant. Working in groups, design and conduct a nutrient experiment in which results will show deficiency and excesses symptoms. Have students record procedure, data, and conclusion. <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, M5, R2,R3, R4, R5, S2, W1, W4, W5</small>	b. Use the <i>Nutrient Deficiencies and Excesses Experiment Rubric (3.8)</i> to evaluate student mastery.
c. Demonstrate the proper procedure for taking a soil sample. (DOK 2)	c. Have students review <i>Soil Testing for the Farmer</i> (http://msucares.com/pubs/infosheets/is0346.pdf) from the Mississippi Cooperative Extension Service and lead a discussion on the “do’s and don’ts” of soil sampling. Using soil probe and bucket, demonstrate soil sampling techniques on school campus. <small>CS1, CS2, CS5, T4, T6, R4, W1, W2</small>	c. Use the <i>Daily Participation Checklist (3.9)</i> to evaluate student mastery.
d. Predict the effect various pH levels will have on plant	d. Refer to Figure 9-6 in the text (Biondo & Lee, 2003, p. 159), and discuss pH effect on nutrient availability. Using the soil sample taken from	d. Use the <i>Plant Nutrition PowerPoint</i>

nutrition and growth. (DOK 4)	campus, demonstrate procedures for pH analysis using proper lab safety procedures. Discuss the effect, if any, pH would have on nutrient availability. Have students add pH effects to their plant nutrient PowerPoint presentation. <small>CS1, CS2, CS4, CS5, T1, T2 T3, T4, T6, R3, R4, R5, W1, W2, W4, W5</small>	<i>Presentation Rubric (3.7)</i> to evaluate student mastery.
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Competency 3: Analyze soil fertility and calculate fertilizer application rates for a specific crop. PS.02, PS.03

<p>Suggested Enduring Understandings</p> <ol style="list-style-type: none"> Plants need nutrients to grow effectively. Plants will not grow and/or produce food at optimum levels unless proper nutrients are provided. 	<p>Suggested Essential Questions</p> <ol style="list-style-type: none"> Why is it important to have soil analyzed before applying fertilizer? How many pounds of 13-13-13 fertilizer must be used to apply 1 lb of nitrogen per 1,000 ft² on a lawn that measures 5,000 ft²? What types of equipment is used to apply fertilizer?
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Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Analyze a soil sample for nutrient deficiencies by using the scientific method. (DOK 4)	a. Place students in three groups. Have at least one student in each group provide soil samples of sand, silt, and clay and discuss properties of each soil type. Have each group analyze a soil sample for pH and nutrient deficiencies and complete the <i>Soil Test Summary Report (3.10)</i> . <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, R2, R3, R4, R5, W1, W2, W4, W5</small>	a. Evaluate <i>Soil Report Summary (3.10)</i> for accuracy and completeness.
b. Calculate fertilizer application rates to meet nutritional requirements for a specific crop. (DOK 2)	b. Discuss and demonstrate the procedure for calculating fertilizer application rates based on soil test recommendations and fertilizer analysis. Provide students with the <i>Fertilizer Calculation Worksheet (3.11)</i> and have them complete it in class. <small>CS2, T2, T4, T6, R4, W2, M5</small>	b. Evaluate <i>Fertilizer Calculation Worksheet (3.11)</i> for accuracy and completeness.
c. Select fertilizer application methods for different plant enterprises. (DOK 1)	c. Using the University of California – Davis PowerPoint presentation Fertilizer Applications , discuss the different methods and timings in applying fertilizers to different crops. <small>CS2, T2, T4, T6, R4, W2, M5</small>	c. Multiple choice questions on written test Questions for the test can be pulled from <i>Mississippi MCT Biology Sample Questions (3.4)</i> or <i>Questions for Unit Test (3.12)</i> .

Standards

AFNR Industry Standards

- PS.01. Apply knowledge of plant classification, plant anatomy, and plant physiology to the production and management of plants.
- PS.02. Prepare and implement a plant management plan that addresses the influence of environmental factors, nutrients, and soil on plant growth.
- PS.03. Propagate, culture, and harvest plants.

Applied Academic Credit Standards

Biology I

- BIOI 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BIOI 2 Describe the biochemical basis of life, and explain how energy flows within and between the living systems.
- BIOI 4 Analyze and explain the structures and function of the levels of biological organization.

Biology II

- BIOII 2 Describe and contrast the structures, functions, and chemical processes of the cell.

Botany

- BO 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BO 2 Distinguish among the characteristics of botanical organization, structure, and function.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS4 Productivity & Accountability
- CS 5 Leadership and Responsibility

National Education Technology Standards for Students (NETS)

- T1 Creativity and Innovation
- T2 Communication and Collaboration
- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- R1 Main Ideas and Author's Approach
- R2 Supporting Details
- R3 Sequential, Comparative, and Cause–Effect Relationships
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- M5 Graphical Representations
- W1 Expressing Judgments
- W2 Focusing on the Topic

W4 Organizing Ideas
W5 Using Language

Suggested References

- Biondo, R. J., & Lee, J. S. (2003). *Introduction to plant and soil science technology* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Biondo, R. J., & Lee, J. S. (2002). *Introduction to plant and soil science technology activity manual* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Biology Web. (n.d.). *Mitosis, introductory concepts*. Retrieved June 9, 2010, from <http://faculty.clintoncc.suny.edu/faculty/michael.gregory/files/Bio%20101/Bio%20101%20Lectures/Mitosis/mitosis.htm#Haploid,%20Diploid>
- Burton, L., & Cooper, E. (2007). *Agriscience: Fundamentals and applications* (4th ed.). Clifton Park, NJ: Thomson Delmar.
- CEV Video. (n.d.). *CEV pathway: Plant systems pathway* [DVD]. Lubbock, TX: Author.
- Chemicool.com. (2008). *Chemistry: Periodic table and more*. Retrieved on June 9, 2010, from <http://www.chemicool.com/>
- Groleau, R. (2001). Nova Online. *How cells divide: Mitosis vs. meiosis*. Retrieved on June 9, 2010, from <http://www.pbs.org/wgbh/nova/miracle/divide.html>
- Colorado State University Extension. (n.d.). *Garden notes #233: Calculating fertilizer application rates*. Retrieved on June 9, 2010 from <http://www.cmg.colostate.edu/gardennotes/233.pdf>
- Mississippi State Cooperative Extension Service. (n.d.). *Soil testing for the farmer*. Retrieved June 9, 2010, from <http://msucares.com/pubs/infosheets/is0346.pdf>
- Mississippi State University Cooperative Extension Service. (n.d.). *Crops*. Retrieved June 9, 2010, from <http://msucares.com/crops/index.html>
- Mitosis and Meiosis*. (n.d.). Retrieved June 9, 2010, from http://biologyinmotion.com/cell_division/index.html
- University of California – Davis. (n.d.). *Fertilizer applications*. Retrieved June 9, 2010, from www.calaged.org/ResourceFiles/Curriculum/supplemental/300Plant/340/345/345.ppt
- For additional references, activities, and web resources, please refer to: Information and Computer Technology B.R.I.D.G.E. Web site: <http://www.rcu.blackboard.com> (Available only to registered users).

Science of Agricultural Plants

Unit 4: Plant Classification and Physiology

15 Hours

Competency 1: Examine plant classification methods.

PS.01, PS.02, PS.03, BIOI 2, BIOI 3, BIOI 6, BIOII 2, BIOII 5, BO 2, BO 5

Suggested Enduring Understandings

1. The scientific classification system was developed to allow scientists to have a universally recognized name for a plant and to classify plants according to their characteristics.
2. Types of plants are grouped together according to their characteristics.
3. Through biotechnology, plant breeders develop new varieties that offer genetic characteristics of disease and insect resistance, drought tolerance, higher yields, and different color flowers to farmers and consumers.
4. Annuals, biennials, and perennials are three common life cycles of plants.
5. There are some types of plants that thrive better when produced in a controlled environment. This type of growing environment is beneficial to growers producing these plants in a mass production system.
6. Some of these types of plants that do better in a controlled environment are bedding and seasonal potted plants. Bedding plants are typically installed with other plants for visual appeal in a landscaping design.

Suggested Essential Questions

1. Why do we classify plants?
2. What plant characteristics are commonly used to identifying plants?
3. Why is variety selection important?
4. What are the differences in the three common life cycles of plants?
5. What are the reasons plants should be produced in a controlled environment?
6. What are some common types of bedding and seasonal potted plants?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Interpret the scientific classification of plants. (DOK 1)	a. Show students a picture of a common plant that is grown across the world (i.e., corn). Ask students to name the plant (using a common name). Point out that this plant may have an entirely different common name in China or England. To allow people across the world to identify and describe using a universal name, the scientific classification system has been developed and accepted. Review the nomenclature of the scientific classification system beginning with kingdom and going through	a. Use the <i>Classification Poster Rubric (4.1)</i> to evaluate student mastery.

species. Tour campus and/or greenhouse on a weekly basis, and introduce students to the classification of a new plant each week. The students will be responsible for verbally identifying the scientific name of each plant during that week. Give each student an index card, and ask him or her to write down the name of his or her favorite plant and write down or draw sketches of 2–5 characteristics of the plant. To help students choose, teacher could provide resources such as textbooks, seed catalogs, seed company websites, and/or the USDA plant database Web site. Using information from the USDA NRCS plant database Web site (<http://plants.usda.gov/>), have students create a poster that includes scientific classification of their favorite plant. Make the poster assignment a competition with rewards for winners that include being able to pick something from the “happy table” or give “reward coupons.” CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, M5, R2, R4, W2

<p>b. Discuss variety and variety selection of various plants. (DOK 2)</p>	<p>c. Divide students into pairs, and assign each student an agronomic or horticultural crop. Have students search the Mississippi State University Extension Service Web site for variety recommendations and compile a list of different factors that must be considered in selecting a variety (yield, color, insect, disease, and drought resistance, response to day length, etc.). Bring the students back into a large group, and use PowerPoint or the White Board to compile a list of common characteristics used in selecting a specific variety. Have students include the listing in their electronic notebooks. <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, R2, R4, W2</small></p>	<p>b. Use the <i>Daily Participation Rubric (4.2)</i> to evaluate student participation in the discussion.</p>
<p>d. Classify plants according to life cycle. (DOK 1)</p>	<p>e. Review the three different life cycles of plants. Provide students <i>Annual, Biennial, or Perennial (4.3)</i> assignment, and have students conduct a search on the Internet to determine the life cycle of each plant. <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, R2, R4, W2</small></p>	<p>c. Evaluate <i>Annual, Biennial, or Perennial (4.3)</i> assignment for accuracy and completeness.</p>
<p>f. Identify three common bedding and seasonal potted plants. (DOK 1)</p>	<p>g. Use the <i>Bedding Plant Keyword Exercise (4.8)</i> to identify keywords, and discuss their meaning and application in bedding plant production. <small>CS1, CS2, CS4, T2, T3, T4, R1, R2, R4, W2, W4, W5</small></p> <p>Seasonal Examples: Easter lilies, poinsettias, and chrysanthemums</p> <p>Bedding Examples: begonias, impatiens, geraniums, petunias, pansies, and marigolds</p>	<p>d. Use the <i>Daily Participation Rubric (4.2)</i> to evaluate student participation in this exercise.</p> <p>Use a <i>Show What You Know</i></p>

Give each student two pieces of different colored paper (Example: yellow and red) similar to index card size. Using a marker, ask students to write down each of the categories in large print (yellow for bedding and red for seasonal). Provide students with live examples or pictures of commonly grown bedding and seasonal potted. As you show each example, ask students to hold up the card colored coded to represent the category name. Discuss each example as you go through them and why each is classified in that particular group. Go through examples again to see how many right answers occur the second time around. CS1, CS2, CS4, T1, T2, T4, R5, W1, W2, W4, W5

competition to evaluate student performance on this indicator. Students could provide an award for winning group. Show pictures of bedding plants, and have the students identify each plant.

h. Grow a greenhouse crop. (DOK 4)

i. Discuss how the [Plant Hardiness Zone Map for Mississippi and Other States](#) is used to select, and schedule bedding plant production. Have students select and schedule plants to be produced in time for planting. Students should choose plant(s) suited for the season and zone to be grown sexually or asexually. Assign students in pairs to be responsible for planting and caring for a flat of bedding plants. Have students maintain records of the plants during the growing period using the *Bedding Plant Production Data Sheet (4.9)*. CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, M5, R3, R4, R5, S2, W1, W2, W4

e. Evaluate the students' records for accuracy and completeness.

Competency 2: Investigate plant anatomy. PS.01, BO 2, BO 3, BO 5

Suggested Enduring Understandings

1. Plants are the only organism that produces its own food.
2. Plants have four main structures: roots, stems, leaves, and flowers.
3. Each structure performs functions that are critical for the survival of the plant species.
4. Roots absorb water and minerals and anchor the plant.
5. Stems hold the leaves and flowers and transport water and nutrients from the roots to the leaves.
6. The function of flowers is to reproduce the species.

Suggested Essential Questions

1. What important function do plant leaves serve?
2. Where does transpiration take place in a leaf?
3. What are the two types of tissue responsible for transporting water, food, and nutrients in plants?
4. What are the collective terms for the male and female parts of a flower?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Identify the types and structures of leaves. (DOK 1)	a. Say to students: The largest leaves grow on the Amazon water lily. In a single year, the plant will produce leaves of more than 2 m (6.6 ft) across. Ask what happens in a leaf. Have students read in (Biondo & Lee, 2003, p. 50) the section on leaves. Make reference to figures 3-17, 3-18, and 3-19. Complete handout taken from the activity manual (Biondo, 2002, p.19). If time allows, let students color in leaf parts on handout. <small>CS1, CS2, CS4, T1, T3, T4, M4, R2, R4, W2, W4</small>	a. Evaluate the handout taken from the activity manual (Biondo, 2002, p.19) for accuracy and completeness.
b. Draw and label the parts of a leaf, and describe their functions. (DOK 2)	<p>b. To help students become excited about leaves, take a group <i>Leaf Walk</i>. During the walk, ask students questions such as the following:</p> <ul style="list-style-type: none"> ▪ Do the leaves have alternate or opposite leaf arrangement? ▪ What type of margin does the leaf have? ▪ Is the leaf simple or compound? ▪ What are the characteristics of the plant? ▪ Is the plant healthy? ▪ What does the plant need to grow better? <p>Have students bring in leaves <i>on a stem</i> to class (at least five different types). Using figures 15-13, 15-14, and 15-16 (Burton & Cooper, 2007, pp. 295–297), have students draw a sketch of their leaves identifying margins, shape, arrangement, and parts of their leaf specimen. Have students read out loud from text (Biondo & Lee, 2003) about leaves. <small>CS1, CS2, CS4, T1, T3, T4, M4, R2, R4, W2, W4:</small></p>	b. Evaluate student drawings for clarity and accuracy.
c. Draw and label the parts of a stem, and describe their functions. (DOK 2)	c. Give students four blank sheets of copy paper. Have students fold the paper in half to make a booklet. Give students the <i>Stems, Roots, and Flowers Booklet Rubric (4.4)</i> , and discuss grading criteria. Have students create a title page (for example: <i>Plant Structures, Plant Parts</i>), name included. Students could use their leaf samples to create an illustration on the title page. Have students draw, label, and briefly describe each type of stem in their booklets. <small>CS1, CS2, CS4, T1, T3, T4, M4, R2, R4, W2, W4</small>	c. Use the <i>Stems, Roots, and Flowers Booklet Rubric (4.4)</i> to evaluate student mastery.
d. Draw and label the types and parts of a root, and describe	d. Read out loud from text about roots (Burton & Cooper, 2007, p. 288). Have live examples adventitious roots, fibrous, and taproot to observe. Examine plant roots (i.e., carrot) in Root View Growth Chamber. Have students draw, label, and briefly describe each type of	d. Use the <i>Stems, Roots, and Flowers Booklet Rubric (4.4)</i> to evaluate

their functions. (DOK 2)	root system. <small>CS1, T2, T3, T4, R2, R4, R5, W1, W2</small> Have students draw, label, and describe each type of root including root structure (Burton & Cooper, 2007, Fig. 15-6, p. 291) in their booklets. <small>CS1, CS2, CS4, T1, T3, T4, M4, R2, R4, W2, W4</small>	student mastery.
e. Identify the types and structure of a flower. (DOK 2)	e. Provide students with the <i>Flower Structure Handout</i> taken from the activity manual (Biondo, 2002, p. 20). Prepare a cross section of a flower to observe under a microscope. Working in groups of two, have students label the flower diagram on the handout while observing under the microscope. Example: Hibiscus flowers While students are waiting to view flower structure under the microscope, they could be working on booklets. <small>CS1, CS2, CS4, CS5, T1, T2, T4, T6, M5, R1, R2, R3, R4, W2, W4, W5</small>	e. Evaluate the Flower Structure Handout for accuracy and completeness.
f. Draw and label the parts of a complete flower, and describe their functions. (DOK 2)	f. Read out loud from the text (Burton & Cooper, 2007, p. 298) about flowers. Have students draw, label, and briefly describe the cross section of an apple (Burton & Cooper, 2007, Fig. 15-19, p. 299) and the major parts of a flower (Burton & Cooper, 2007, Fig. 15-18, p. 299) in their booklets. <small>CS1, CS2, CS4, T1, T3, T4, M4, R2, R4, W2, W4</small>	f. Use the <i>Stems, Roots, and Flowers Booklet Rubric (4.4)</i> to evaluate student mastery.

Competency 3: Assess physiological principles of plants. PS.01, BIOI 2, BIOII 2, BO 2, CHI 5

Suggested Enduring Understandings

1. Photosynthesis is the most important process on the planet because it replenishes oxygen and manufactures the basic food supply for animals.
2. Plants are the only living organisms that can make their own food.
3. In many tropical areas of the world, there are huge forests. These are often known as the “lungs of the world” because they produce oxygen. These forests are really important because they reduce the amount of carbon dioxide in the air.

Suggested Essential Questions

1. How do plants obtain food energy?
2. What are the starting reactants for photosynthesis?
3. What are the end products of photosynthesis?
4. What factors affect the rate of photosynthesis?
5. What are the starting reactants for cellular respiration?
6. What are the end products of cellular respiration?

Suggested Performance	Suggested Teaching Strategies	Suggested Assessment
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Indicators		Strategies
<p>a. Describe photosynthesis, including the chemical reactions that occur. (DOK 2)</p>	<p>a. Photosynthesis literally means to build with light. Provide students with the <i>Photosynthesis, Respiration, and Transpiration Information Sheet (4.5)</i>. Discuss this information, making reference to photosynthesis and respiration formulas and beginning and end products. Draw the comparison table on an overhead projector or white board, and have students complete it and record in electronic notebooks.</p> <p>Challenge Activity: Use the Photosynthesis and Plant Pigment Kit to demonstrate the role of light, chlorophyll, carbon dioxide, and oxygen in photosynthesis. <small>CS 1, CS4, T1, T2, T4, T6, S2</small></p>	<p>a. Use the <i>Photosynthesis, Respiration, and Transpiration Information Sheet (4.5)</i> and <i>Transpiration Activity (4.6)</i> for student mastery.</p>
<p>b. Describe the process of respiration and transpiration. (DOK 2)</p>	<p>b. Cover this competency simultaneously with photosynthesis and transpiration discussion. (See the <i>Photosynthesis, Respiration, and Transpiration Information Sheet (4.5)</i>.) <small>CS1, CS4, T1, T2, T4, T6, S2</small></p> <p>Introduce the concept of plant transpiration by asking students what they think happens when they exhale (breathe out) when they are outside on a very cold day. For students who have lived in or experienced cold climates, they should recall the interesting phenomenon of “seeing your breath.” A person’s exhaled breath is what releases water vapor and other gases from their lungs. Plants emit water vapor through their leaves mainly by a process called transpiration. Although “seeing your breath” is not an identical process to plant transpiration, it provides students with a conceptual model to help them understand what occurs when plants release (transpire) water vapor. The human body and plant leaves are both moist on the inside, and when gases from inside animals or plants are released to the outside, these gases carry water vapor with them. Reinforce transpiration concepts with the <i>Transpiration Activity (4.6)</i> or the <i>Transpiration in Plants</i> activity from the activity manual (Biondo, 2002, p. 21).</p> <p>Challenge Activity: <i>Coloring Flowers</i>. The Web site shown below has a good explanation of the transpiration process and experimental suggestion varying temperature effects. http://www.madsci.org/experiments/archive/887562625.Bi.html <small>CS1, CS2, CS4, CS5, T2, T3, T4, T6, R1, R2, R3, R4, R5, W2, W4, W5</small></p>	<p>b. Use the <i>Photosynthesis, Respiration, and Transpiration Information Sheet (4.5)</i> and <i>Transpiration Activity (4.6)</i> for student mastery.</p>
<p>c. Explain how each plant part</p>	<p>c. Create a crossword puzzle that plant parts and their association to growth and development of the plant. (EclipseCrossword is a Web site for creating free crossword puzzles.) <small>CS1, CS2, CS4, T1, T2, T4,</small></p>	<p>c. Completion of crossword</p>

and process
is
important
in the
growth and
developme
nt of a
plant. (DOK
2)

R4, R5, W1, W2, W4, W5

puzzle

Use the
*Plant
Classification
and
Physiology
Unit Test
(4.7)* to
evaluate
student
mastery of
the unit.

Standards

AFNR Industry Standards

PS.01. Apply knowledge of plant classification, plant anatomy, and plant physiology to the production and management of plants.

Applied Academic Credit Standards

Biology I

BIOI 2 Describe the biochemical basis of life and explain how energy flows within and between the living systems.

BIOI 6 Demonstrate an understanding of principles that explain the diversity of life and biological evolution.

Biology II

BIOII 2 Describe and contrast the structures, functions, and chemical processes of the cell.

BIOII 5 Develop an understanding of organism classification.

Botany

BO 2 Apply inquiry-based and problem-solving processes and skills to scientific investigations.

BO 3 Demonstrate an understanding of plant reproduction.

BO 5 Relate an understanding of plant genetics to its uses in modern living.

Chemistry I

CHI 5 Compare factors associated with acid/base and oxidation/reduction reactions.

21st Century Learning Standards

CS1 Flexibility & Adaptability

CS2 Initiative & Self-Direction

CS4 Productivity & Accountability

CS5 Leadership & Responsibility

National Education Technology Standards for Students (NETS)

T1 Creativity and Innovation

T2 Communication and Collaboration

T3 Research and Information Fluency

T4 Critical Thinking, Problem Solving, and Decision Making

T6 Technology Operations and Concepts

ACT College Readiness Standards

M4 Expressions, Equations, and Inequalities

M5 Graphical Representations

R1 Main Ideas and Author's Approach

R2 Supporting Details

R3 Sequential, Comparative, and Cause–Effect Relationships

R4 Meaning of Words

R5 Generalizations and Conclusions

- S2 Scientific Investigation
- W1 Expressing Judgments
- W2 Focusing on the Topic
- W4 Organizing Ideas
- W5 Using Language

Suggested References

Biondo, R. J., & Lee, J. S. (2003). *Introduction to plant and soil science technology* (2nd ed.). Lebanon, IN: Interstate Publishing.

Biondo, R. J., & Lee, J. S. (2002). *Introduction to plant and soil science technology activity manual*. Lebanon, IN: Interstate Publishing.

Burpee seeds and plants for home gardens. (n.d.). Retrieved on June 9, 2010, from www.burpee.com

CEV Video. (n.d.). *CEV Pathway: Plant Systems Pathway* [DVD]. Lubbock, TX: Author.

Burton, L.D., & Cooper, E.L. (2007). *Agriscience fundamentals and applications* (4th ed.). Albany, NY: Delmar.

Eclipse crossword. (n.d.). Retrieved on June 9, 2010, from <http://www.eclipsecrossword.com/>

Gurney's seed and nursery. (n.d.). Retrieved on June 9, 2010, from <http://gurneys.com>

Marimore, R. (1998). *Coloring plant transpiration*. Retrieved on June 9, 2010, from <http://www.madsci.org/experiments/archive/887562625.Bi.html>

Park seed company. (n.d.). Retrieved on June 9, 2010, from www.parkseed.com

Plant parts - structures and functions. (n.d.). Retrieved June 9, 2010, from <http://www.hcs.ohio-state.edu/mgonline/Botany/pla01/00pla01.htm>

Okonek, B., & Organstein, L. (1996). *Classification of plants*. Retrieved on June 9, 2010, from <http://www.accessexcellence.org/RC/Ethnobotany/page3.php>

QUIA. (n.d.). *Photosynthesis and respiration*. Retrieved June 9, 2010, from <http://www.quia.com/jg/122289list.html>

EPA for Students and Educators | Resources. (n.d.) *EPA for students and educators*. Retrieved June 9, 2010, from <http://www.epa.gov/epahome/students.htm>

USDA. (n.d.). *Plants database*. Retrieved on June 9, 2010, from <http://plants.usda.gov/>

For additional references, activities, and web resources, please refer to: Mississippi Agriculture Education B.R.I.D.G.E. Web site: <http://www.rcu.blackboard.com> (Available only to registered users).

Science of Agricultural Plants

Unit 5: Plant Reproduction and Propagation

20 Hours

Competency 1: Examine the principles of genetics. PS.01, BIOI 4, BIOI 5, BIOI 6, BIOII 2, BIOII 3, BIOII 4, BO 2, BO 5, BO 4, G 1, G 2, G 3

Suggested Enduring Understandings

1. Variations in plants are caused by the pairing of dominant and recessive genes from the two parent plants, i.e. Gregor Mendel.
2. The cell is the basic unit of a living plant and is composed of several different organelles that perform functions necessary for cell growth and division.
3. The nucleus of each plant cell contains genetic information that controls the characteristics of a plant. This information is contained in long molecular chains of deoxyribonucleic acid (DNA). Each DNA chain is composed of pairs of genes that control specific characteristics of the plant.

Suggested Essential Questions

1. How do the basic laws of genetics cause variations in plants?
2. What is the molecular chain that stores genetic information in all living cells?
3. Where is genetic information stored in the cell?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Explain the principles of Mendel’s law. (DOK 1)	a. Have students try to roll their tongues, and describe how this is a genetic trait that is inherited from one of their parents. Instructors should limit the activity to two traits. Have students read the information sheet <i>Mendel’s Law and Punnett Squares (5.1)</i> and discuss the terms and principles associated with Mendel’s law. Have students draw the Punnett square in their notebooks and complete results. <small>CS2, CS4, T4, M5, R1, R2, R3, R4, R5, W2, W4</small>	a. Have students peer evaluate and correct the three Punnett square problems found in the information sheet.
b. Investigate the structure of a plant cell. (DOK 2)	b. Make signs with names of cell organelles (12) for each student to hang around his or her neck. Have students research the purpose of each organelle and draw a picture of the organelle on the sign. Have students role-play their organelle. <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, M5, R1, R2, R3, R4, R5, W2, W4, W5</small>	b. Use the <i>Daily Participation Rubric (5.2)</i> to evaluate student understanding.
c. Identify the makeup of chromosomes in a	c. Have students read out loud from the text (Biondo & Lee, 2003, p. 62) about offspring	c. Use the <i>Daily Participation Rubric (5.2)</i> to

plant cell. (DOK 1)	and genetics. Have students locate handout from <i>Unit 3</i> in their activity manual (Biondo, 2002) and review mitosis and meiosis. <small>CS1, CS4, T3, T4, M5, R1, R2, R3, R4, W2, W4</small>	evaluate student understanding.
d. Describe the structure of DNA. (DOK 2)	d. Review from the text (Biondo & Lee, 2003, p. 62) about offspring and genetics. Have students arrange a model of DNA showing the structure and pairing and placement of genes on the DNA as shown in the <i>DNA Structure Activity (5.3)</i> in this unit. Several variations can be used for a model. The following <i>Double Helix Model</i> Web site uses Styrofoam balls. Instructors can use beads and chenille sticks with students to demonstrate the creation of a DNA model. Students can refer to the activity manual (Biondo, 2002, p. 62) as a guide. <small>CS1, CS2, CS4, T1, T2, T4, M5, R2, R4, W2, W4</small>	d. Evaluate student accuracy and completeness in constructing the DNA model.

Competency 2: Distinguish between sexual and asexual reproduction. PS.01, PS.03, BIOI 1, BIOI 4, BO 1, BO 3

Suggested Enduring Understandings

1. Plants reproduce sexually by producing seed that contains a plant embryo and plant food surrounded by a seed wall.
2. The rate of germination is dependent on a number of factors including type of seed, quality of seed, seed treatment, temperature and light conditions, and moisture.
3. Asexual reproduction involves the reproduction of plants through the use of plant parts (roots, cuttings, explants, etc.). Asexual reproduction produces a plant that is genetically identical to the parent plant.
4. Traditional methods of plant propagation include cuttings, grafting, layering, separation, and division.
5. A newer, highly technical method of plant propagation is tissue culture.

Suggested Essential Questions

1. What advantage does sexual reproduction provide to a plant?
2. What conditions are needed for good seed germination?
3. What is seed viability, and how is it determined?
4. What are the advantages of asexual plant reproduction?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe sexual reproduction in plants. (DOK 1)	<p>a. Use the following metaphor to recall by association: sexual reproduction and seed; the two S's. Have students read out loud from (Biondo & Lee, 2003, pp. 59–61) about sexual plant reproduction. Discuss Fig. 4-3, and make a connection between parts of the flower that develop into the fruit we eat (i.e., ovary develop into fruit and ovules develop into seed). Demonstrate by cutting open a fruit (i.e., watermelon) or discussing fruit parts in Fig. 4-7. <small>R3, R4, W1, W2</small></p>	<p>a. Use a written test to evaluate student understanding.</p> <p>Questions can be used from <i>Unit Test Questions (5.6)</i> to create the test.</p>
b. Describe the conditions needed for good seed germination. (DOK 1)	<p>b. Lead a discussion about the relationship between good seed germination conditions and what students already know about spring plantings. Have students read out loud from (Biondo & Lee, 2003, pp. 65–68). Use a metaphor to recall information by association that stratification connects with stratus and cold; scarification connects with scaring of seed coat by animal stomach acid. <small>CS1, T2, T4, R1, R2, R3, R4, G5, W2, W4, W5</small></p>	<p>b. Use a written test to evaluate student understanding.</p> <p>Questions can be used from <i>Unit Test Questions (5.6)</i> to create the test.</p>
c. Plan and conduct a seed germination test. (DOK 3)	<p>d. Show an example of a certified seed label, and describe/discuss the elements that it contains (purity, viability, inert matter, noxious weeds, etc.).</p> <p>Set up an experiment using equal numbers of acorns, corn, and beans. Place some of each seed in moist peat moss in a refrigerator and others in moist peat moss in the greenhouse, culture incubator, and classroom. Make observations, and record data over time using the <i>Germination Test Experiment (5.4)</i>. Determine germination as a percentage. Seed test could involve lighting treatment including greenhouse light, artificial light, and no light. Keep records of seeding date and number of seed that germinate each day. Mist daily and water peat moss when necessary. <small>CS1, CS2, CS4, CS5,</small></p>	<p>d. Evaluate the <i>Germination Test Experiment (5.4)</i> for accuracy and completeness.</p>

T1, T2, T3, T4, T6, M1, M2, M5, R1, R2, R3, R4, R5, S1, S2, W1, W2, W4,

W5

d. Identify and describe asexual reproduction methods. (DOK 3)

d. Have students read out loud from the text (Biondo & Lee, 2003, pp 68–72). Have plant material and tools on hand to demonstrate asexual reproduction by cuttings. ^{CS1, CS2, CS4, CS5,}

T1, T2, T3, T4, T6, M1, M2, M5, R1, R2, R3, R4, R5, S1, S2, W1, W2, W4,

W5

e. Evaluate the *Rooting Hormone Experiment Data Collection Sheet (5.5)* for accuracy and completeness.

Obtain rooting hormone, and discuss with students the ingredients. Have students conduct an experiment that compares use of rooting hormone to no rooting hormone (control) while preparing vegetative cuttings.

^{CS1, CS2, CS4, CS5,} T1, T2, T3, T4, T6, M5, R1, R2, R3, R4, R5, S2, W1, W2,

W4, W5

f. Explore asexual plant reproduction techniques using grafting, cuttings, layering, separation and division, and tissue culture methods. (DOK 2)

f. Invite a local horticulturist to demonstrate grafting. Repot plants in greenhouse to demonstrate separation and division methods of asexual plant reproduction. Use the laminar flow hood to practice the aseptic techniques required for tissue culture. Challenge Activity: Use Venus Fly Trap tissue culture kits from Carolina Biological to practice tissue culture lab techniques. ^{CS1, CS2, CS4, CS5,} T1, T2, T3, T4 R3, R4, R5, W2,

W4

f. Use the *Daily Participation Rubric (5.2)* to evaluate student understanding.

Standards

AFNR Industry Standards

- PS.01. Apply knowledge of plant classification, plant anatomy, and plant physiology to the production and management of plants.
- PS.03. Propagate, culture, and harvest plants.

Applied Academic Credit Standards

Biology I

- BIOI 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BIOI 4 Analyze and explain the structures and function of the levels of biological organization.
- BIOI 5 Demonstrate an understanding of the molecular basis of heredity.
- BIOI 6 Demonstrate an understanding of principles that explain the diversity of life and biological evolution.

Biology II

- BIOII 2 Describe and contrast the structures, functions, and chemical processes of the cell.
- BIOII 3 Investigate and discuss the molecular basis of heredity.
- BIOII 4 Demonstrate an understanding of the factors that contribute to evolutionary theory and natural selection.

Botany

- BO 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BO 2 Distinguish among the characteristics of botanical organization, structure, and function.
- BO 3 Demonstrate an understanding of plant reproduction.
- BO 5 Relate an understanding of plant genetics to its uses in modern living.
- BO 4 Draw conclusions about the factors that affect the adaptation and survival of plants.

Genetics

- G 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- G 2 Analyze the structure and function of the cell and cellular organelles.
- G 3 Apply the principles of heredity to demonstrate genetic understandings.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS4 Productivity & Accountability
- CS5 Leadership & Responsibility

National Education Technology Standards for Students (NETS)

- T1 Creativity and Innovation
- T2 Communication and Collaboration
- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- M1 Basic Operations and Applications
- M2 Probability, Statistics, and Data Analysis
- M5 Graphical Representations
- R1 Main Ideas and Author's Approach
- R2 Supporting Details
- R3 Sequential, Comparative, and Cause–Effect Relationships
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- S1 Interpretation of Data
- S2 Scientific Investigation
- W1 Expressing Judgments
- W2 Focusing on the Topic
- W4 Organizing Ideas
- W5 Using Language

Suggested References

BBC-h2g2. (2002). *Gregor Mendel and the basics of genetics*. Retrieved on June 9, 2010, from <http://www.bbc.co.uk/dna/h2g2/A885521>

Biondo, R. J., & Lee, J. S. (2003). *Introduction to plant and soil science technology* (2nd ed.). Lebanon, IN: Interstate Publishing.

Biondo, R. J., & Lee, J. S. (2002). *Introduction to plant and soil science technology activity manual* (2nd ed.). Lebanon, IN: Interstate Publishing.

CEV Video. (n.d.). *CEV pathway: Plant systems pathway* [DVD]. Lubbock, TX: Author.

Center for Biology Education. (n.d.). *Reebops: A model organism for teaching genetics concepts*. Retrieved on June 15, 2010, from www.cosi.org/files/File/exhibits/classactivity-reebops.pdf

Dirr, M., & Heuser, C. JR. (1987). *The reference manual of woody plant propagation. From seed to tissue culture*. Varsity Press, Inc. Athens, GA.

Double Helix DNA Model. (n.d.). Retrieved on June 9, 2010, from <http://www.kidslovekits.com/projects/DNAmodel/index.html>

Kuure-Kinsey, M., & McCooey, B. (2000). *An introduction for recombinant DNA*. Retrieved on June 9, 2010, from <http://www.rpi.edu/dept/chem-eng/Biotech-Environ/Projects00/rdna/rdna.html>

Texas A&M Extension Horticulture. (n.d.). *Frequently asked questions about rDNA biotechnology and foods*. Retrieved on June 9, 2010, from <http://aggie-horticulture.tamu.edu/extension/newsletters/foodproc/oct00/art3oct.html>

Wikipedia Foundation. (n.d.). *Mendelian Inheritance*. Retrieved on June 9, 2010, from http://en.wikipedia.org/wiki/Mendelian_inheritance

For additional references, activities, and web resources, please refer to: Information and Computer Technology B.R.I.D.G.E. Web site: <http://www.rcu.blackboard.com> (Available only to registered users).

Science of Agricultural Plants

Unit 6: Plant Growing Structures

10 Hours

Competency 1: Describe the use of various plant growing structures and their environmental control systems. PS.02, PS.03, BIOI 2, BIOI 3, BIOII 2, BO 2

Suggested Enduring Understandings

1. Greenhouses and other structures are used by horticulturists to extend the growing season and to grow plants that would not normally be grown in the prevailing climate. There are several different types of commercial greenhouses in use today, and selection of a greenhouse type is based on crops to be grown and construction and maintenance costs.
2. Shade cloths are used to protect plants from strong sunlight and wind exposure.
3. While glass was used in the past, most greenhouses today are covered with polycarbonate, polyethylene, or fiberglass materials because of the economical cost of the material and the ease of installation.
4. For optimum plant growth, the greenhouse environment must be controlled to provide the proper temperature, light, humidity, and water level for the plants.
5. Light is essential for plant growth and must be monitored and controlled for intensity, color, and duration. Blue wavelengths affect photosynthesis, and red wavelengths affect flowering and reproduction.

Suggested Essential Questions

1. What is the purpose of a greenhouse?
2. What are the advantages and disadvantages of the different types of greenhouses?
3. Why is shade necessary for some plants?
4. How do you select a covering for a greenhouse?
5. What controls and equipment are used to control the environment within a greenhouse?
6. What factors must be considered in providing light for a greenhouse.
7. What factors must be considered in controlling temperature within a greenhouse?
8. How is plant watering managed in greenhouses?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Identify and compare the greenhouse types: Quonset, ridge and furrow, and even span. (DOK 2)	a. Organize a tour activity using AEST greenhouse. (See the <i>Greenhouse Tour Activity (6.1)</i> in this unit). Identify the different components, controls, and systems that will be covered in this unit. Assign some students to develop a PowerPoint presentation on the different types of greenhouses, their characteristics, and advantages/disadvantages. Assign other students a topic related to the different types of structures and environmental	a. Use the <i>Structure and Control Systems Presentation and Rubric (6.2)</i> to evaluate student mastery.

controls used in these structures, and have them develop and present a PowerPoint presentation. See the *Structure and Control Systems Presentation and Rubric (6.2)* for more instructions for PowerPoint development and presentation criteria. Topics can be assigned to individual students or groups, depending on class size. Have students assigned the topics related to different types of greenhouses make their presentations to the class.

Following each presentation, hold a class discussion to make sure that all key points related to the topic have been covered. Have students summarize the key points from the presentation and place in their electronic journals or notebooks. CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, M5, R1, R2, R4, R5, W2, W4, W5

<p>b. Describe the different types of coverings used on greenhouses. (DOK 2)</p>	<p>b. For this indicator, have student(s) who developed PowerPoint presentations on different types of coverings used on greenhouses including fiberglass, polycarbonates, polyethylene, and shade cloths make their presentations to the class. Following the presentation, hold a class discussion to make sure that all key points have been covered. Have all students summarize the key points in the presentation and record in their electronic journals or notebooks. <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, M5, R1, R2, R4, R5, W2, W4, W5</small></p>	<p>b. Use the <i>Structure and Control Systems Presentation and Rubric (6.2)</i> to evaluate student performance.</p>
<p>c. Differentiate between environmental controls including humidistat, thermostat, cooling, watering, and heating. (DOK 3)</p>	<p>c. For this indicator, have students who developed PowerPoint presentations on different systems for heating, cooling, and controlling humidity and watering make their presentations to the class. Following the presentation, hold a class discussion to make sure that all key points have been covered. Have all students summarize the key points in the presentation and record in their electronic journals or notebooks. <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, M5, R1, R2, R4, R5, W2, W4, W5</small></p>	<p>c. Use the <i>Structure and Control Systems Presentation and Rubric (6.2)</i> to evaluate student performance.</p>
<p>d. Describe the importance of light in plant growth. (DOK 1)</p>	<p>d. Give each student a copy of NASA Predicts Non-Green Plants on Other Planets, and refer to Appendix 6C. Have them review the article and highlight what they consider the top three important points of the article. Throw a ball around to call on students to list their three important points. Keep a tally of how many</p>	<p>d. Use the <i>Daily Participation Rubric (6.3)</i> to evaluate student participation and understanding.</p>

	<p>students listed the same points. Review article contents with the class to make sure that all key points are covered. Have students read out loud about the effects of light colors, duration, and intensity needed for plant growth (Biondo & Lee, 2003, pp.100–103). <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, R1, R2, R3, R4, R5, W2, W4, W5</small></p>	
<p>e. Explain how temperature affects the growth of a plant. (DOK 1)</p>	<p>e. Have students read out loud about the effect of temperature on plant growth. Hold a class discussion on the key points in the material, and have students transcribe them into their electronic notebooks or journals (Biondo & Lee, 2003, pp. 103–105). <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, R1, R2, R3, R4, R5, W2, W4, W5</small></p>	<p>e. Use a written test to evaluate student understanding.</p>
<p>f. Discuss water management in growing plants. (DOK 3)</p>	<p>f. Have students read out loud about the water needs of plants (Biondo & Lee, 2003, pp. 106–108). Discuss water management of plants to be maintained including greenhouse, nursery, campus landscape, and interior school plants. In groups of two, have students maintain water regime for plants and record data using the <i>Plant Water Management Data Sheet (6.4)</i>. Challenge Activity: This assignment can be rotated among classmates with students training each other about water regime requirements. <small>CS1, CS2, CS4, CS5, T2, T3, T4, R3, R5, W1, W4, W5</small></p>	<p>f. Evaluate the <i>Plant Water Management Data Sheet (6.4)</i> to determine student understanding.</p>

Standards

AFNR Industry Standards

- PS.02. Prepare and implement a plant management plan that addresses the influence of environmental factors, nutrients, and soil on plant growth.
- PS.03. Propagate, culture, and harvest plants.
- PST.02. Design, operate, and maintain mechanical equipment, structures, biological systems, land treatment, power, and technology.

Applied Academic Credit Standards

Biology I

- BIOI 2 Describe the biochemical basis of life and explain how energy flows within and between the living systems.
- BIOI 3 Investigate and evaluate the interaction between living organisms and their environment.

Biology II

- BIOII 2 Describe and contrast the structures, functions, and chemical processes of the cell.

Botany

- BO 2 Distinguish among the characteristics of botanical organization, structure, and function.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS4 Productivity & Accountability
- CS5 Leadership & Responsibility

National Education Technology Standards for Students (NETS)

- T1 Creativity and Innovation
- T2 Communication and Collaboration
- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- M5 Graphical Representations
- R1 Main Ideas and Author's Approach
- R2 Supporting Details
- R3 Sequential, Comparative, and Cause–Effect Relationships
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- S2 Scientific Investigation
- W1 Expressing Judgments
- W2 Focusing on the Topic
- W4 Organizing Ideas
- W5 Using Language

Suggested References

- Biondo, R. J., & Lee, J. S. (2003). *Introduction to plant and soil science technology* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Biondo, R. J., & Lee, J. S. (2002). *Introduction to plant and soil science technology activity manual* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Biondo, R. J. (2004). *Greenhouse production*. Lebanon, IN: Pearson Publishing.
- Boodley, J.W. & Newman, S.E. (2009). *The commercial greenhouse* (3rd ed.). Clifton Park, NY: Delmar.
- CEV Video. (n.d.). *CEV pathway: Plant systems pathway* [DVD]. Lubbock, TX: Author.
- Growit.com. (2000). *USDA plant hardiness zone map*. Retrieved June 9, 2010, from <http://www.growit.com/bin/USDAZoneMaps.exe?MyState=MS>
- Redorbit News. (2007). *NASA predicts non-green plants on other planets*. Retrieved June 9, 2010, from http://www.redorbit.com/news/space/898744/nasa_predicts_nongreen_plants_on_other_planets/index.html
- West Virginia University Extension Service. (n.d.). *Planning and building a greenhouse*. Retrieved June 9, 2010, from <http://www.wvu.edu/~Agexten/Hortcult/greenhou/building.htm#Types%20of%20Greenhouses>

Science of Agricultural Plants

Unit 7: Cultural and Harvesting Practices

15 Hours

Competency 1: Examine types of growing media. PS.02, PS.03, E3, BIOI 1, BIOII 1, BO1, ES1, PS1

Suggested Enduring Understandings

1. Soil is a complex substance composed of minerals, water, organic matter, and other materials.
2. Soil texture affects both the productivity and usefulness of land.
3. The Land Capability Classification System is designed to assist in determining the highest productive use of a piece of land.
4. An ideal growing medium for plants is one that provides the plants with adequate supplies of water, air, and minerals.
5. Organic soil amendments such as peat or compost provide water holding capacity and improve the texture of heavy soils.
6. Inorganic soil amendments such as vermiculite or perlite improve soil aeration and drainage.
7. Soilless media is often used in greenhouse and nursery operations because it is usually sterile; uniform and consistent in nutrients, texture, and pH; and easier to handle.
8. Hydroponic plant production is expensive to install but provides greater yields than conventional methods.

Suggested Essential Questions

1. How do the characteristics of soil affect its conservation and use?
2. How is the texture of a soil determined?
3. How is the Land Capability Classification System used to determine highest productive use?
4. What are the characteristics of an ideal growing medium?
5. How do organic soil amendments add to the productivity of a soil or soilless mixture?
6. How do inorganic soil amendments add to the productivity of a soil or soilless mixture?
7. What are the characteristics of a soilless medium?
8. Why is hydroponics being used to produce plants?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Discuss the characteristics and functions of soil components, including minerals, water, organic matter, and other constituents. (DOK 1)	a. Use the Earth Apple activity from the Earth Apple: Land Stewardship Project web site to introduce soil concepts. Ask students if soil is a renewable or nonrenewable resource. Show students an example of a soil profile; tell students that it may take 1,000 years for an inch of topsoil to form. Ask students why they think it takes so long. Have students read out loud from Chapter 7 of the text (Biondo & Lee, 2003) and lead a discussion on the characteristics and functions of the different soil components. ^{CS1, CS2, T2, R4, R5, W1, W2, W4, W5}	a. Use the <i>Group Participation Rubric (7.1)</i> to evaluate student mastery.
b. Determine soil	b. Review the section on soil particle size and on the	b. Evaluate the <i>Soil</i>

<p>texture. (DOK 2)</p>	<p>use of a soil triangle in Chapter 7 of the text (Biondo & Lee, 2003). Set up samples of sand, silt, clay, and organic matter in petri dishes for students to view under the microscope. Have soil samples available for students to evaluate their textures using both microscope and ribbon method. Using the soil triangle, students record soil classification on the <i>Soil Data Summary Sheet (7.2)</i>. <small>CS1, CS2, CS4, CS5, T2, T4, T6, M5, R1, R2, R3, R4, R5, W1, W2, W4, W5</small></p>	<p><i>Data Summary Sheet (7.2)</i> for accuracy and completeness.</p>
<p>c. Apply principles of land capability to determine highest productive use and homesite evaluation capability. (DOK 3)</p>	<p>c. How easy is it to cultivate and grow crops on a mountain? What type of land do you think has highest crop production? Review the land capability classes guidelines in the text (Burton & Cooper, 2007). Discuss and demonstrate the use of land evaluation forms in <i>Instructions on Land Judging in Mississippi</i> to evaluate a chosen land area using the <i>Mississippi Land Judging Scorecard (7.3)</i>. <small>CS1, CS2, CS4, CS5, T4, R1, R2, R3, R4, W2</small></p>	<p>c. Evaluate the <i>Mississippi Land Judging Scorecard (7.3)</i> for accuracy and completeness.</p>
<p>d. Identify the characteristics of an ideal growing medium. (DOK 1)</p>	<p>d. What happens if a plant gets too dry? What happens if a plant gets too wet? Live examples would help students visualize answers. Review the section on soil structure from the text (Biondo & Lee, 2003), and discuss the characteristics of an ideal plant growth medium. <small>CS1, CS2, CS4, CS5, T2, T4, T6, R1, R2, R4, R5, W1, W2, W4, W5</small></p>	<p>d. Use a written test to evaluate student performance.</p>
<p>e. Discuss the characteristics of organic soil amendments including bark, compost, leaf mold, and peat moss. (DOK 2)</p>	<p>e. Use the Soil Organism Kit to conduct a laboratory activity to extract nematodes and other microscopic organisms from the soil. Use the microscope camera to project microorganisms in organic material. Discuss results and emphasize importance of organic matter in the soil. Show students examples of bark and peat moss. Discuss characteristics of drainage and water holding capacity. Develop a compost pile. Have students plant a tree or shrub on campus incorporating the soil with one of the organic soil amendments listed in objective. <small>CS1, CS2, CS4, CS5, T1, T2, T4, R3, R4, W1, W2, W4</small></p> <p>Display examples of perlite, vermiculite, and commercial potting media, and identify the characteristics they add to a plant growth medium (perlite, vermiculite, sand, etc.). Have empty bags of commercial potting media for students to read contents. Discuss soilless growing media components and characteristics. <small>CS1, T2, R4, R5, W1, W2</small></p> <p>Conduct an experiment to test characteristics of various types of growing media. Include inorganic</p>	<p>e. Use the <i>Group Participation Rubric (7.1)</i> to evaluate student performance.</p> <p>Use a written test to evaluate student performance on this indicator.</p>

	soil amendments discussed in indicator e above and other soil and soilless types of media. Seedlings grown in the Plant Reproduction Unit can be used for this experiment. <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, M5, R3, R4, R5, S2, W1, W2, W4, W5</small>	Use the <i>Media Experiment Data Sheet and Rubric (7.5)</i> to evaluate student understanding and performance on this indicator.
f. Discuss the advantages and disadvantages of hydroponics plant production. (DOK 3)	f. Show students the Hydroponic Lettuce video . Have students design a booklet that includes drawings of different hydroponics systems and include a table listing advantages and disadvantages. <small>CS1, CS2, CS4, CS5, T1, T2, T4, M5, R1, R2, R3, R4, W2</small>	f. Use the <i>Hydroponics Booklet Rubric (7.4)</i> to evaluate student performance on this indicator.

Competency 2: Explore tillage, irrigation practices, harvesting methods, and harvest timing. PS.01, PS.02,

PS.03, E4, ES2, NRS 04

Suggested Enduring Understandings

1. Many producers are switching to limited or no-till production practices in order to conserve fuel and limit soil compaction and erosion.
2. When a soil or growing medium is allowed to become too dry or to become too wet, plant growth is reduced, and plants become more prone to disease and insect damage.
3. Many producers are now installing irrigation systems to insure that adequate moisture is available to plants at all times. Irrigation systems can range from a sprinkler can in a greenhouse to a center pivot system in a 160-acre field.
4. Generally speaking, water for irrigation should be pure enough to drink and should not contain excessive amounts of harmful salt.
5. Harvesting is the process of moving plants or plant products from the field into storage or a market or processing plant.
6. Harvesting procedures vary depending on the plant being grown, timing and season, storage procedures, perishability, harvest methods, and pre and post-harvest losses.

Suggested Essential Questions

1. What are the advantages of limited tillage or no-till farming methods?
2. How does soil or growing medium moisture affect the growth of plants?
3. What are the different types of irrigation systems, and what production systems are they applicable to?
4. What effect does water quality have on irrigation and plant growth?
5. What factors affect when a crop or plant is harvested?

Suggested

Suggested Teaching Strategies

Suggested

Performance Indicators		Assessment Strategies
a. Compare traditional tillage and planting equipment and procedures to limited or no-till planting. (DOK 2)	a. Allow students to use the tiller on school campus. Show students pictures of traditional tillage, planting equipment, and limited and no-till planting. In groups of two or three, have students review research publications that compare traditional tillage to limited tillage and no-till planting. Students will identify three important components of the article to write on board or easel paper to discuss with the class. <small>CS2, CS4, T1, T2, T3, T4, R1, R1, R4, R5, W2, W4</small>	a. Use the <i>Group Participation Rubric (7.1)</i> to evaluate student mastery.
b. Discuss the role of moisture management in plant production. (DOK 3)	b. Have students read out loud from the section on <i>Moisture Management</i> from the text (Biondo & Lee, 2003). Tour the greenhouse and school campus to evaluate water needs of plants depending on soil type, light, and plant characteristics. Assign students certain plants to care for, take pictures, and develop a plant maintenance log for students to records. Use the soil moisture meter and light meter to add quantitative data. <small>CS1, CS2, CS4, CS5, T2, T4, M5, R2, R3, R4, R5, W1, W2, W3, W4</small>	b. Use the <i>Plant Maintenance Log Rubric (7.6)</i> to evaluate student mastery.
c. Define irrigation, and describe hand drip and sprinkler/mist irrigation systems. (DOK 2)	c. Have students read the section on <i>Irrigation Application Methods</i> from the text (Biondo & Lee, 2003). Show students the PowerPoint presentation <i>Irrigation Equipment Options</i> on different types of irrigation systems. Set up an irrigation system in greenhouse or on campus, or have students observe irrigation systems in local garden centers and/or farm fields, or take a field trip to wholesale nurseries or farms. Give students 5 minutes to construct a paragraph summarizing the key points about irrigation after brainstorming and writing keywords on the board. <small>CS2, CS4, CS5, T4, R5, W1, W2, W4, W5</small>	c. Use the <i>Paragraph Construction Rubric (7.7)</i> to evaluate student mastery.
d. Determine water quality for irrigation. (DOK 1)	d. Have students read out loud about quality irrigation water from the section on <i>Quality Irrigation Water</i> in the text (Biondo & Lee, 2003). Show students pots with soluble salt build up on drainage holes. Students should participate in a lab exercise to determine soluble salts in water. <small>CS2, T3, T4, R1, R2, W1, W2, W4</small>	d. Use a written test to evaluate student performance. Use the chart in the text (Boodley, 1998, p. 293).
e. Explore different harvesting methods. (DOK 2)	e. Begin by asking students why harvesting of plants is important. Set the stage for a <i>Dirty Jobs</i> activity where students will develop a PowerPoint presentation involving the harvest of plants or plant products and then role-play their job in harvesting.	e. Use the <i>Dirty Jobs Presentation Rubric (7.9)</i> to evaluate the students'

Divide the class into groups of two to three presentations. students, and assign each group a specific plant or plant product that is grown locally. This may include field crops, timber, nursery and greenhouse crops, or forage crops. Have students develop a PowerPoint presentation that reflects the types of products harvested from the plants, harvest timing, harvest methods and equipment, storage procedures for harvested products, preharvest and post-harvest losses, and perishability of the products. CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T6, R2, R3, R4, R5, W2, W2, W4, W5

Competency 3: Examine sustainable agriculture practices in plant production. PS.02, PS.03, PST.05, E3, E4, ES 1, ES 2, ES 3, NRS.01, NRS.03, NRS.04, NRS.05, PS.04, SP 1, SP 2

Suggested Enduring Understandings

1. Sustainable agriculture involves the conservation and management of natural resources so that these resources can continue to be used to produce over future generations.
2. A point source of pollution can be identified to one specific place. A nonpoint source of pollution comes from many different places.
3. Soil and water conservation methods are designed to protect soil and water supplies while still allowing them to be used to produce food and other products.
4. Precision farming is a relatively new technique that employs the use of microcomputers, geographic information software, global positioning systems, remote sensing, and machinery controllers to reduce costs and increase yields in crops.

Suggested Essential Questions

1. How do sustainable agriculture practices enhance and protect the environment?
2. What is the difference in point and nonpoint pollution sources?
3. What are the common soil and water conservation methods, and how do they contribute to the environment?
4. What is precision farming, and why is it being used more frequently?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe how the concept of sustainable agriculture protects and enhances the environment. (DOK 2)	a. Prior to teaching this competency, have students read the section on <i>Sustainable Resource Use</i> from the text (Biondo & Lee, 2003). Use the <i>Concept Map</i> activity from the activity manual (Biondo, 2002) to lead a class discussion on ideas related to sustainability. After the discussion, have students draw concept maps for a given enterprise. <small>CS2, CS4, T4, M5, R1, R2, R3, R4, R5, W2, W4</small>	a. Evaluate students' concept maps for completeness and accuracy.
b. Distinguish	b. Have students write down definition of point and	b. Use the <i>Group</i>

<p>between point and nonpoint pollution sources. (DOK 2)</p>	<p>nonpoint pollution. Using a Pictionary Activity, the instructor should develop a handout with pictures of various types of point and nonpoint pollution sources, like Pictionary cards, place student in groups, and use pictograph game rules. <small>CS1, CS2, CS4, CS5, T1, T2, T4, R2, R3, R4, R5, W2, W2, W4, W5</small></p>	<p><i>Participation Rubric (7.1)</i> to evaluate student mastery.</p>
<p>c. Describe soil and water conservation methods used in agriculture. (DOK 1)</p>	<p>c. After discussing methods of soil and water conservation, have students develop a poster or computer graphic following the rules set up by the National Association of Conservations Districts (http://www.nacdnet.org/education/contests/poster/). Invite a representative of the local Natural Resource Conservation Service office to help score posters and speak on conservation issues and solutions. <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, R1, R2, R3, R4, R5, W2, W4</small></p>	<p>c. Use the <i>Soil and Water Conservation Graphic Rubric (7.10)</i> to evaluate the graphics created by the students.</p>
<p>d. Describe precision farming. (DOK 1)</p>	<p>d. Prior to teaching this competency, have students read the section on <i>Precision Farming</i> from the text (Biondo & Lee, 2003). Have a guest speaker from a local community college or extension service to discuss precision farming and provide an overview of the major components of a precision farming system (microcomputers, GIS, GPS, and controllers). Have students take notes and follow up the presentation with questions and comments. List important points on the LCD projector, and have students enter these points into their electronic notebooks or journals. <small>CS1, CS3, CS4, T3, T6, R1, R2, R4, W2, W4, W5</small></p>	<p>d. Use the <i>Guest Speaker Evaluation Form (7.8)</i> to evaluate student mastery.</p>

Standards

AFNR Industry Standards

- NRS.01. Explain interrelationships between natural resources and humans necessary to conduct management activities in natural environments.
- NRS.02. Apply scientific principles to natural resource management activities.
- NRS.03. Apply knowledge of natural resources industries to production and processing industries.
- NRS.04. Demonstrate techniques used to protect natural resources.
- NRS.05. Use effective methods and venues to communicate natural resource processes to the public.
- PS.01. Apply knowledge of plant classification, plant anatomy, and plant physiology to the production and management of plants.
- PS.02. Prepare and implement a plant management plan that addresses the influence of environmental factors, nutrients, and soil on plant growth.
- PS.03. Propagate, culture, and harvest plants.
- PST.05 Apply technology principles in the use of agricultural technical systems.

Applied Academic Credit Standards

Earth Science

- E3 Discuss factors which are used to explain the geological history of earth.
- E4 Demonstrate an understanding of earth systems relating to weather and climate.

Environmental Science

- ES 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- ES 2 Develop an understanding of the relationship of ecological factors that affect an ecosystem.
- ES 3 Discuss the impact of human activities on the environment, conservation activities, and efforts to maintain and restore ecosystems.

Spatial Information Science

- SP 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- SP 2 Develop an understanding of geographic information systems.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS3 Social & Cross-Cultural Skills
- CS4 Productivity & Accountability
- CS5 Leadership & Responsibility

National Education Technology Standards for Students (NETS)

- T1 Creativity and Innovation
- T2 Communication and Collaboration
- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- M1 Basic Operations and Applications
- M5 Graphical Representations
- R1 Main Ideas and Author's Approach
- R2 Supporting Details
- R3 Sequential, Comparative, and Cause–Effect Relationships
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- W1 Expressing Judgments
- W2 Focusing on the Topic
- W4 Organizing Ideas
- W5 Using Language

Suggested References

- Biondo, R. J., & Lee, J. S. (2003). *Introduction to plant and soil science technology* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Biondo, R. J., & Lee, J. S. (2002). *Introduction to plant and soil science technology activity manual* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Boodley, J.W. & Newman, S.E. (2009). *The commercial greenhouse* (3rd ed.). Clifton Park, NY: Delmar.
- CEV Video. (n.d.). *CEV pathway: Plant systems pathway* [DVD]. Lubbock, TX: Author.
- Burton, L.D., & Cooper, E.L. (2007). *Agriscience fundamentals and applications* (4th ed.). Albany, NY: Delmar.
- Earth Apple: Land Stewardship Project*. (n.d.). Retrieved on June 9, 2010, from http://www.maswcd.org/Youth_Education/Education_2002_2003_Soils/earth_apple.pdf
- Field, H. (2002). *Agricultural field equipment* (Videotape). Athens, GA: AAVIM.
- VidoEmo. *Discovery how its made hydroponic lettuce production*. (n.d.). Retrieved June 9, 2010, from <http://www.vidoemo.com/yvideo.php?i=V21xOVNQcWuRpUGdVcGM&discovery-how-its-made-hydroponic-lettuce-production>
- Kelly, L. (n.d.). *Irrigation Equipment Options* [PowerPoint]. Retrieved June 9, 2010, from http://www.msue.msu.edu/objects/content_revision/download.cfm/revision_id.455294/works_pace_id.28699
- Mississippi State University Cooperative Extension Service. (n.d.). *Instructions on land judging in Mississippi*. Retrieved June 9, 2010, from <http://msucares.com/pubs/publications/p0679.pdf>
- National Association of Conservation Districts. (n.d.). *Poster contest*. Retrieved June 9, 2010, from <http://www.nacdnet.org/education/contests/poster/#2009>

Science of Agricultural Plants

Unit 8: Pest Management

10 Hours

Competency 1: Assess the effects of pests on plant production. PS.03 , FPP.02, NRS.04, BIOI 3, BIOI 6, BO 4

Suggested Enduring Understandings

1. The three common categories of plant pests are weeds, insects, and diseases.

Suggested Essential Questions

1. What are the most common insect, weed, and disease plant pests?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
<p>a. Identify types of plant pests (insects, wildlife, diseases, and weeds), and describe how each type of pest affects production. (DOK 1)</p>	<p>a. Have students read out loud about from the section on Management of Plant Pests in the text (Biondo & Lee, 2003). Have students collect weed samples from school campus and/or greenhouse and bring them back to the classroom. Use the Web site Weeds of Lawns, Yards and Flowerbeds in Mississippi to project images of different weeds and identify the weeds collected. Identify types of weeds collected. Have students identify insect and disease problems in the greenhouse; collect and observe under a microscope. While observing, instructor could include comments about host plants and susceptibility, resistance to pesticides, and biological control methods. Instructor should tailor further instruction according to crops grown in the area.</p> <p>The types of plant pests instruction should cover the following:</p> <p>Insects</p> <ul style="list-style-type: none"> ○ Siphoning ○ Chewing ○ Sucking ○ Piercing <p>Diseases</p> <ul style="list-style-type: none"> ○ Fungus ○ Viruses ○ Bacteria <p>Weeds</p> <ul style="list-style-type: none"> ○ Annuals ○ Perennials ○ Biennials <p>Wildlife</p> <ul style="list-style-type: none"> ○ Raccoon 	<p>b. Evaluate the <i>Pest Identification Chart (8.1)</i> for accuracy and completeness.</p> <p>The plant pest brochure should be graded by a presentation rubric.</p>

- Deer
- Rabbit
- Armadillo

Have students collect at least 10 pests and enter the appropriate information on the *Pest Identification Chart (8.1)*. The students will create a brochure describing the types of plant pests with their characteristics. CS1, CS2, CS4, CS5, T2, T4, R3, R4, R5, W1, W2, W4

Competency 2: Examine concepts of plant pest control. NRS.01, NRS.04, PS.03, BIOI 3, BIOI 6, BO 4

Suggested Enduring Understandings

1. Pest control may be achieved by means of biological, chemical, cultural, and mechanical methods.
2. Many insects are actually beneficial to plants since they prey on other insects that damage plants.
3. Crop rotation plays an important role in pest control by disrupting insect, weed, and disease cycles.

Suggested Essential Questions

1. How are biological and cultural pest control methods related?
2. What are examples of biological, chemical, and mechanical plant pest controls?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Discuss the relationship between biological, chemical, cultural, and mechanical control methods. (DOK 2)	a. Use the <i>Insect Populations Critical Thinking Activity</i> in the text (Biondo & Lee, 2003) to help students understand how pest populations multiply. Have students review text material covered in the sections related to integrated pest management, insect and nematode management, plant disease management, and weed management from the text (Biondo & Lee, 2003). Have students develop a table biological, chemical, cultural, and mechanical control methods and compare similarities. Instruction can be reinforced using greenhouse activities. <small>CS2, CS4, T4, M5, R1, R2, R3, R4, R5, W4</small>	a. Evaluate the biological, chemical, cultural, and mechanical control comparison table for accuracy and completeness.
b. Identify beneficial insects, and discuss how they benefit plants. (DOK 2)	b. Have students investigate one of the beneficial insects listed below and prepare a <i>Beneficial Insects Ag News Report (8.2)</i> that includes a picture of the insect, plants that are associated with the insect, and pests that they aid in controlling. Students should share their findings with the class. <small>CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, R1, R2, R3, R5, W1, W2, W4, W5</small>	b. Use the <i>Beneficial Insects Ag News Report (8.2)</i> that to evaluate student mastery.

Beneficial Insects

-
- Ladybugs
 - Parasitic wasps
 - Praying mantis
 - Bees
-

c. Interpret safety precautions and formulations on pesticide labels. (DOK 2)

c. Use the Environmental Protection Agency [Read the Label First](#) Web site to allow students to read about the information that is required to be printed on a pesticide label. Assign a specific chemical pesticide to each student, and have him or her search for label information on the web and complete the *Pesticide Label Interpretation Assignment (8.3)* to interpret that information. CS1, CS2, CS4, CS5, T3, T6, R2, R3, R4, R5, W1, W2, W4, W5

c. Evaluate the assignment for completion and accuracy.

d. Design an integrated pest management plan for a designated crop. (DOK 3)

d. Divide the class into groups of two to three students, and assign each student a specific crop to design an integrated pest management plan. Using the Internet and other resources, the plan should include the name of the crop, typical pests encountered, and a description of cultural, mechanical, biological, and chemical methods what will be integrated for control of all pests. CS1, CS2, CS4, CS5, T1, T2, T3, T4, T6, R2, R3, R4, R5, W1, W2, W4, W5

d. Use the *Integrated Pest Management Plan Rubric (8.4)* to evaluate the IPM.

The instruction should cover crops including the following:

- Corn
 - Cotton
 - Wheat
 - Soybeans
-

Standards

AFNR Industry Standards

- FPP.02. Apply safety principles, recommended equipment, and facility management techniques to the food products and processing industry.
- NRS.01. Explain interrelationships between natural resources and humans necessary to conduct management activities in natural environments.
- NRS.04. Demonstrate techniques used to protect natural resources.
- PS.03. Propagate, culture, and harvest plants.

Applied Academic Credit Standards

Biology I

- BIOI 3 Investigate and evaluate the interaction between living organisms and their environment.
- BIOI 6 Demonstrate an understanding of principles that explains the diversity of life and biological evolution.

Botany

- BO 4 Draw conclusions about the factors that affect the adaptation and survival of plants.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS4 Productivity & Accountability
- CS5 Leadership & Responsibility

National Education Technology Standards for Students (NETS)

- T1 Creativity and Innovation
- T2 Communication and Collaboration
- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- M5 Graphical Representations
- R1 Main Ideas and Author's Approach
- R2 Supporting Details
- R3 Sequential, Comparative, and Cause–Effect Relationships
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- W2 Focusing on the Topic
- W4 Organizing Ideas
- W5 Using Language

Suggested References

- Bayer Environmental Science. (n.d.). *Pesticide selection and application procedures*. Retrieved June 9, 2010, from http://www.backedbybayer.com/Bayer/CropScience/BackedByBayer.nsf/id/EN_Pesticide_Selection_Application_Procedures
- Biondo, R. J., & Lee, J. S. (2003). *Introduction to plant and soil science technology* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Biondo, R. J., & Lee, J. S. (2002). *Introduction to plant and soil science technology activity manual* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Byrd, J. (n.d.). *Weeds of lawns, yards, and flowerbeds in Mississippi*. Retrieved June 9, 2010, from <http://www2.msstate.edu/~jbyrd/turfweed.html>
- CEV Video. (n.d.). *CEV pathway: Plant systems pathway* [DVD]. Lubbock, TX: Author.
- Eartheasy.com. (2004–2008). *Garden insectary*. Retrieved June 9, 2010, from http://www.eartheasy.com/grow_garden_insectary.htm
- Frontline. (2002). *Food-borne illness*. WGBH Educational Foundation. Retrieved June 9, 2010, from <http://www.pbs.org/wgbh/pages/frontline/shows/meat/safe/foodborne.html>
- Mead, P.S., Slutsker L., Dietz, V., McCaig, L.F., Bresee, J.S., Shapiro, C., Griffin, P.M., and Tauxe, R.V. (2001). *Food-related illness and death in the United States*. Retrieved June 9, 2010, from <http://www.cdc.gov/ncidod/eid/Vol5no5/mead.htm>
- Online information service for non-chemical pest management in the tropics (OISAT)*. (n.d.). PAN Germany. Retrieved June 9, 2010, from http://www.oisat.org/control_methods/cultural_practices/crop_rotation.html
- Ontario Ministry of Agriculture Food & Rural Affairs. (n.d.). *No-till: Making it work crop rotation*. Retrieved June 9, 2010, from http://www.omafra.gov.on.ca/english/environment/no_till/crop.htm
- U. S. Environmental Protection Agency. (n.d.). *Read the label first*. Retrieved June 9, 2010, from <http://www.epa.gov/pesticides/label/>
- U. S. Fish and Wildlife Service. (n.d.). *Integrated pest management: Guidance for preparing and implementing integrated pest management plans*. Retrieved June 9, 2010, from <http://www.fws.gov/Contaminants/Documents/GuidanceIPMPlan.pdf>

Science of Agricultural Plants

Unit 9: Marketing in Plant Production

5 Hours

Competency 1: Examine marketing practices used in crop and plant production. ^{ABS.06}

Suggested Enduring Understandings

1. Economic factors such as supply and demand and economies of scale affect the selection of crops and plants to be produced.
2. Usually several different markets are available, and marketing and transportation costs must be considered in selecting a market.

Suggested Essential Questions

1. How do economic factors affect plant production?
2. What markets are usually available for plant and crop products? How is a market selected?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Identify economic factors to consider in crops and plants to be produced. (DOK 1)	a. Prior to teaching this competency, have the students read the chapter on Marketing in the text (Burton & Cooper, 2007). Use the Marketing presentation (Osksa, n.d.) to lead a discussion of some basic concepts of crop marketing including utility, law of demand, law of supply, equilibrium price, price discovery, and economies of size. Have students summarize major points and definitions and record in their electronic notebooks or journals. ^{CS1, CS2, CS4, T3, T6, W4, W5}	a. Use a written test to evaluate student understanding.
b. Explore market availability. (DOK 1)	b. Lead a discussion on the pros and cons of different marketing options for plants and crop products such as sales to the public, wholesalers, retailers, cooperatives, regional and terminal markets, and direct sales to processors. Have students build a table in their electronic notebooks that summarizes the major points for each market option. ^{CS1, CS2, CS4, T3, T6, W4, W5}	b. Use a written test to evaluate student understanding.

Competency 2: Explore the economics of plant production. ^{ABS.06}

Suggested Enduring Understandings

1. The cash, futures, retail, and wholesale markets are all affected by the same forces. When one of these markets rises, the others usually follow.
2. The futures market can be used by producers to hedge against a loss in the cash market or as an investment by speculators.
3. In today's global economy, a factor that affects

Suggested Essential Questions

1. How are the different markets (cash, futures, retail, and wholesale) related to each other?
2. How is the futures market used by producers and speculators?
3. What are some issues arising from global

the market in one country will impact on the marketing? markets in other countries.

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Differentiate between cash, futures, and wholesale and retail markets. (DOK 1)	a. Define the four different types of markets, and discuss the differences between the four different types of markets. Have students show how the four markets are related to and affect each other over time. <small>CS1, CS2, CS4</small>	a. Use a written test to evaluate student understanding.
b. Discuss the use of the futures market as a tool for hedging against risk and as a tool for speculation. (DOK 1)	b. Use the presentation Using Futures (Georgia Agricultural Education Curriculum Office, 2002) to acquaint students with the basic operation of the futures markets to “hedge” against a loss. Explain that producers use the futures market to “lock in” a price on their grain. Speculators are people who do not have grain to sell in the cash market but speculate that the futures price will either rise or fall before the contract closes. Have students track and graph prices on the cash and futures market over time to see the relationship between the two. <small>CS1, CS2, CS4, T3, T6, M5</small>	b. Evaluate student assignment to track prices over time on the cash and futures markets for accuracy and correctness.
c. Explore global marketing issues for crop and plant products. (DOK 1)	c. Have students track and graph commodity prices over a period of 1 month at several international markets for crops such as soybeans, rice, and wheat (London, Chicago, Hong Kong, Sao Palo, etc.). Have students note reasons for changes in prices and also note the relationship between the markets. <small>CS1, CS2, CS4, T3, T6, M5, S1</small>	c. Check graph and notes for accuracy and correctness.

Standards

AFNR Industry Standards

ABS.06. Use industry-accepted marketing practices to accomplish AFNR business objectives.

21st Century Learning Standards

- CS1 Flexibility & Adaptability
- CS2 Initiative & Self-Direction
- CS4 Productivity & Accountability

National Education Technology Standards for Students (NETS)

- T3 Research and Information Fluency
- T6 Technology Operations and Concepts

ACT College Readiness Standards

- M5 Graphical Representations
- R1 Main Ideas and Author's Approach
- R2 Supporting Details
- R4 Meaning of Words
- R5 Generalizations and Conclusions
- S1 Interpretation of Data
- W2 Focusing on the Topic
- W4 Organizing Ideas
- W5 Using Language

Suggested References

- Biondo, R. J., & Lee, J. S. (2003). *Introduction to plant and soil science technology* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Biondo, R. J., & Lee, J. S. (2002). *Introduction to plant and soil science technology activity manual* (2nd ed.). Lebanon, IN: Interstate Publishing.
- Burton, L., & Cooper, E. (2007). *Agriscience: Fundamentals and applications*. (4th ed.). Clifton Park, NJ: Thomson Delmar.
- CEV Video. (n.d.). *CEV pathway: Plant systems pathway* [DVD]. Lubbock, TX: Author.
- Georgia Agricultural Education Curriculum Office. (2002). *Using futures*. (presentation). Retrieved June 9, 2010, from http://aged.ces.uga.edu/Browseable_Folders/Power_Points/Marketing/Commodity_Marketing_Using_Futures.ppt
- Molnar, J. (n.d.). *New directions in Alabama agriculture: Niches, chains, and relationships* (PowerPoint). Retrieved June 9, 2010, from http://www.ag.auburn.edu/auxiliary/BC/PAGESL1/2004Conference/2004ConfPagesL2/2004FinalReport/2004FinalReport_EachPerson/MolnarJoseph/New%20Directions%20in%20Alabama%20Agriculture%208%20November.ppt
- Osksa, C. (n.d.). *Marketing* (Powerpoint). Retrieved June 9, 2010, from http://aged.ces.uga.edu/Browseable_Folders/Power_Points/Marketing/Marketing_Casey_Oksa.ppt
- Pennsylvania State University College of Agricultural Sciences. (n.d.). *Niche marketing*. Retrieved June 9, 2010, from <http://agmarketing.extension.psu.edu/Business/NicheMktg.html>

Student Competency Profile

Student Name: _____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It can be duplicated for each student and serve as a cumulative record of competencies achieved in the course.

In the blank before each competency, place the date on which the student mastered the competency.

Unit 1: Introduction to Agricultural Plants

- _____ 1. Examine how plants are used to meet human and environmental needs.
- _____ 2. Examine plant production enterprises.
- _____ 3. Demonstrate career and leadership skills required for employment in the plant industry.
- _____ 4. Demonstrate general safety precautions for the laboratory and greenhouse.

Unit 2: Experiential Learning (SAE)

- _____ 1. Plan and implement an experiential learning program.
- _____ 2. Maintain records and documentation of experiential learning activities, projects, and enterprises.

Unit 3: Plant Growth and Nutrition

- _____ 1. Examine the principles of plant growth.
- _____ 2. Discuss basic principles of plant nutrition and soil pH.
- _____ 3. Analyze soil fertility, and calculate fertilizer application rates for a specific crop.

Unit 4: Plant Classification and Physiology

- _____ 1. Examine plant classification methods.
- _____ 2. Investigate plant anatomy.
- _____ 3. Assess physiological principles of plants.

Unit 5: Plant Reproduction and Propagation

- _____ 1. Examine the principles of genetics.
- _____ 2. Distinguish between sexual and asexual reproduction.

Unit 6: Plant Growing Structures

- _____ 1. Describe the use of various plant growing structures and their environmental control systems.

Unit 7: Cultural and Harvesting Practices

- _____ 1. Examine types of growing media.
- _____ 2. Explore tillage, irrigation practices, harvesting methods, and harvest timing.
- _____ 3. Examine sustainable agriculture practices in plant production.

Unit 8: Pest Management

- _____ 1. Assess the effects of pests on plant production.
- _____ 2. Examine concepts of plant pest control.

Unit 9: Marketing in Plant Production

- _____ 1. Examine marketing practices used in crop and plant production.
- _____ 2. Explore the economics of plant production.

Name:
Date:
Period:

Plant Production Fact Sheet (1.2)

Your teacher will assign you a plant that is produced for food, fiber, or ornamental purposes. Use the Internet and other sources to compile a fact sheet similar to the one shown below.

Insert a picture of the plant here.

What is the common name of the plant?

What is the scientific name of the plant?

What parts of this plant are useful, and what are they used for?

What is the growing season for this plant? Where does it grow?

How is this crop planted or reproduced?

What are the major cultural practices associated with this crop?

How is this crop harvested or sold? Where are the closest markets for this crop?

What are the estimated costs and returns for growing this crop?

Name: _____

Date: _____

Period: _____

21st Century Life and Career Skills (1.3)

Today's life and work environments require far more than thinking skills and content knowledge. The ability to navigate the complex life and work environments in the globally competitive information age requires students to pay rigorous attention to developing adequate life and career skills.

CS1 Global Awareness

1. Using 21st century skills to understand and address global issues
2. Learning from and working collaboratively with individuals representing diverse cultures, religions, and lifestyles in a spirit of mutual respect and open dialogue in personal, work, and community contexts
3. Understanding other nations and cultures, including the use of non-English languages

CS2 Financial, Economic, Business, and Entrepreneurial Literacy

1. Knowing how to make appropriate personal economic choices
2. Understanding the role of the economy in society
3. Using entrepreneurial skills to enhance workplace productivity and career options

CS3 Civic Literacy

1. Participating effectively in civic life through knowing how to stay informed and understanding governmental processes
2. Exercising the rights and obligations of citizenship at local, state, national, and global levels
3. Understanding the local and global implications of civic decisions

CS4 Health Literacy

1. Obtaining, interpreting and understanding basic health information and services and using such information and services in ways that enhance health
2. Understanding preventive physical and mental health measures, including proper diet, nutrition, exercise, risk avoidance, and stress reduction
3. Using available information to make appropriate health-related decisions
4. Establishing and monitoring personal and family health goals
5. Understanding national and international public health and safety issues

CS5 Environmental Literacy

1. Demonstrate knowledge and understanding of the environment and the circumstances and conditions affecting it, particularly as relates to air, climate, land, food, energy, water, and ecosystems
2. Demonstrate knowledge and understanding of society's impact on the natural world (e.g., population growth, population development, resource consumption rate, etc.)
3. Investigate and analyze environmental issues, and make accurate conclusions about effective solutions
4. Take individual and collective action towards addressing environmental challenges (e.g., participating in global actions, designing solutions that inspire action on environmental issues)

CSS2-Learning and Innovation Skills

CS6 Creativity and Innovation

1. Think Creatively

2. Work Creatively with Others
3. Implement Innovations

CS7 Critical Thinking and Problem Solving

1. Reason Effectively
2. Use Systems Thinking
3. Make Judgments and Decisions
4. Solve Problems

CS8 Communication and Collaboration

1. Communicate Clearly
2. Collaborate with Others

CSS3-Information, Media and Technology Skills

CS9 Information Literacy

1. Access and Evaluate Information
2. Use and Manage Information

CS10 Media Literacy

1. Analyze Media
2. Create Media Products

CS11 ICT Literacy

1. Apply Technology Effectively

CSS4-Life and Career Skills

CS12 Flexibility and Adaptability

1. Adapt to change
2. Be Flexible

CS13 Initiative and Self-Direction

1. Manage Goals and Time
2. Work Independently
3. Be Self-directed Learners

CS14 Social and Cross-Cultural Skills

1. Interact Effectively with others
2. Work Effectively in Diverse Teams

CS15 Productivity and Accountability

1. Manage Projects
2. Produce Results

CS16 Leadership and Responsibility

1. Guide and Lead Others
2. Be Responsible to Others

Name: _____

Date: _____

Period: _____

Rubric for Evaluating Life and Career Skills (1.4)

The following scale can be used to assess application of each of the Life and Career Skills of students.

Superior	(18–20 points) The student consistently demonstrates all aspects of this skill in classroom and laboratory activities.
Exceptional	(15–17 points) The student consistently demonstrates most of the aspects of this skills in classroom and laboratory activities but lapses at times on one to two of the indicators.
Adequate	(12–14 points) The student demonstrates knowledge of the skill during classroom and laboratory activities but lapses on three or more indicators from time to time.
Improving	(9–11 points) The student is vaguely aware of the skill but shows only marginal evidence of being able to apply it in the classroom or laboratory.
Minimal	(0–8 points) The student consistently fails to demonstrate knowledge or application of the skill.

Skill	Comments	Score
Flexibility and Adaptability		
Initiative & Self-Direction		
Social & Cross-Cultural Skills		
Productivity & Accountability		
Leadership & Responsibility		
		TOTAL SCORE

Name: _____

Date: _____

Period: _____

Rubric for Evaluating Role-Play on Behavior (1.5)

	Excellent 4 Points	Good 3 Points	Average 2 Points	Needs Improvement 1 Point	Score
Accuracy	All information was accurate.	Almost all information was accurate.	Most information was accurate.	Very little information was accurate.	
Role	Excellent character development; student contributed in a significant manner	Good character development; student contributed in a cooperative manner	Fair character development; student may have contributed	Little or no character development; student did not contribute much at all	
Knowledge Gained	Consistently showed specific knowledge of proper and improper behavior	Showed general knowledge of proper and improper behavior	Showed limited knowledge of proper and improper behavior	Did not show any knowledge of proper and improper behavior	
Props	Used several props and showed considerable creativity	Used one or two appropriate props that made the presentation better	Used one or two props that made the presentation better	Used no props to make the presentation better	
Required Elements	Included more information than required	Included all required information	Included most required information	Included less information than required	
TOTAL					

Comments:

Name: _____

Date: _____

Period: _____

Interpret a Materials Safety Data Sheet Worksheet (1.6)

Your instructor will assign you a common material found in agricultural enterprises that can pose a hazard to your health or the environment. Using the Internet, search for information to answer the following questions.

1. What is the common name of this material?
2. How hazardous is this material to your health?
3. If you accidentally drank or ate some of this material, what should you do?
4. If you accidentally spilled some of this material, what should you do?
5. How should you store this material?
6. If you no longer need this material, how should you dispose of it?

Name: _____

Date: _____

Period: _____

HACCP Fact Sheet Evaluation Rubric (1.7)

	Exemplary	Accomplished	Developing	Beginning	Score
Content	Content is accurate and detailed and applies to agricultural production practices. (60 points)	Content is accurate but general in nature with some application to agricultural practices. (45 points)	Content is accurate but general in nature with limited application to agricultural practices. (30 points)	Content does not focus on assigned topic, is inaccurate, or is totally unrelated to agricultural practices. (10 points)	
Grammar	Correct and effective use of grammar and mechanics (20 points)	Occasional minor errors in use of grammar and mechanics (15 points)	Problems in use of grammar and mechanics (10 points)	Repeated errors in use of grammar and mechanics (5 points)	
Organization	Ideas flow smoothly and logically with clarity and coherence. (20 points)	Logical order and appropriate sequencing of ideas with adequate transition (15 points)	Some evidence of an organizational plan or strategy (10 points)	Lacks organization (5 points)	
Total					

Comments

Name: _____

Date: _____

Period: _____

Rubric for Experiential Learning Planning and Record Keeping (2.1)

Scoring Criteria				
	Excellent 4	Good 3	Needs Improvement 2	Unacceptable 1
Long-range and short-term goals reflect the educational and career goals of the student.				
The SAE plan/training agreement reflects growth in student skill and proficiency.				
Records accurately reflect all SAE accomplishments of the student over the year.				
Records are maintained on a timely basis.				
Journals or calendars are maintained on a timely basis and serve as the source for record keeping.				
Hours and earnings are recorded based on activities.				
A summary of all activities is provided at the end of each grading period.				
Financial records are maintained accurately.				
Financial records are summarized at the end of the year.				

Name: _____

Date: _____

Period: _____

Pre-Knowledge Assessment Example (3.1)

What I Already Know

Questions you could ask to stimulate thinking	MITOSIS	MEIOSIS
Where does mitosis/meiosis take place in plants?	Roots, stems, leaves, flower parts	Only in reproductive cells
	Asexual reproduction	Sexual reproduction
What results in greater genetic variation?	Duplication of genetic makeup	Genetic variation
How are the chromosomes divided in the new cells?	Same number of chromosomes	Cells with half the number of chromosomes

Note to Instructor: Below is an explanation for the questions in the table above.

What do chromosomes do?

Mitosis produces two daughter cells that are identical to the parent cell. If the parent cell is **haploid (N)**, then the daughter cells will be haploid. If the parent cell is diploid (**2N**), the daughter cells will also be diploid.

N N

2N 2N

This type of cell division allows multicellular organisms to grow and repair damaged tissue.

Meiosis produces daughter cells that have one half the number of **chromosomes** as the parent cell.

2N N

Taken from

<http://faculty.clintoncc.suny.edu/faculty/michael.gregory/files/Bio%20101/Bio%20101%20Lectures/Mitosis/mitosis.htm#Haploid,%20Diploid>

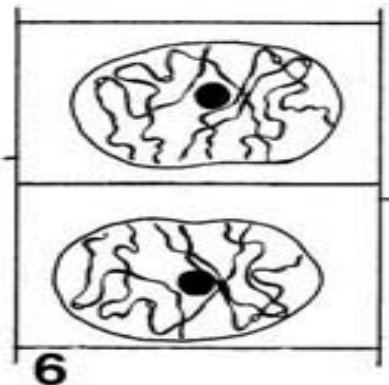
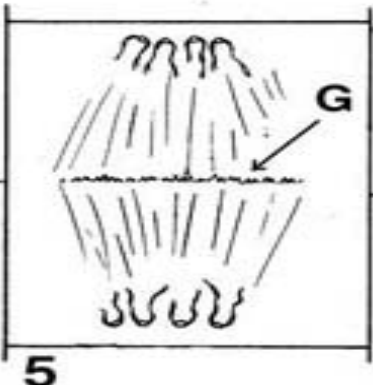
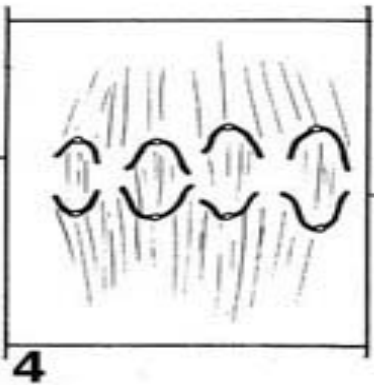
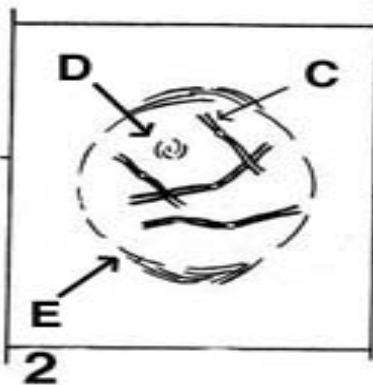
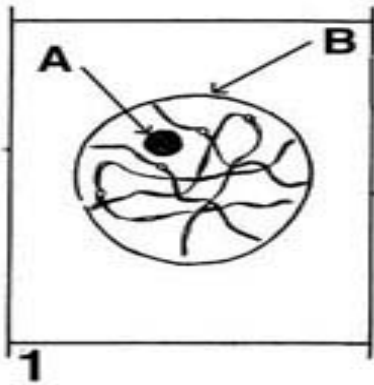
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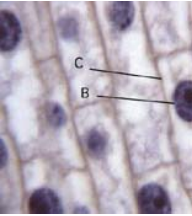
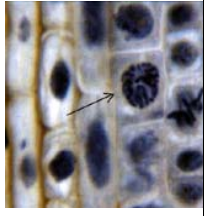
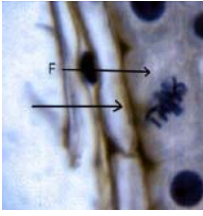
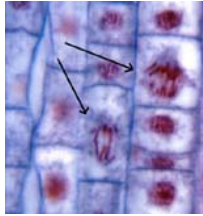
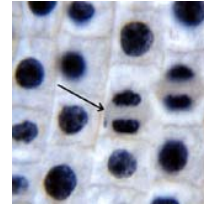
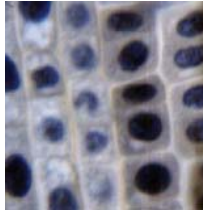
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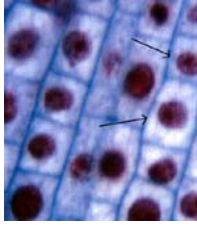
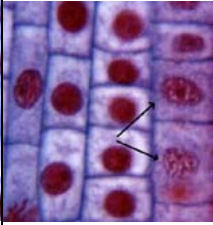
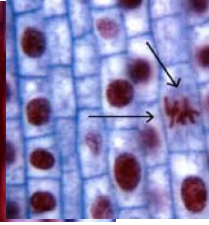
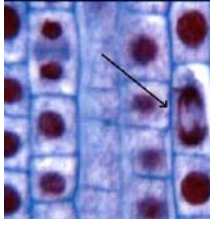
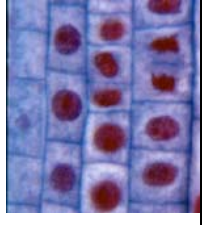

Period: _____

Onion Root Mitosis Activity (3.2)

DIRECTIONS: Check out the onion root slides, and read descriptions of each stage of mitosis on the following pages; then label the diagram.



					
<p>This onion cell is in the interphase stage of the cell cycle. Early in interphase the cell reaches its full size and then starts preparing for its next division. Preparation includes chromosome replication, replication of cellular organelles, and the synthesis of microtubules. Distinct chromosomes are not visible at this time, but the nuclear region appears prominent after staining (B). Nucleoli also are present during interphase, and a single nucleolus is shown in the photo above (A). The cell wall (C) clearly identifies the cell as being from a plant.</p>	<p>The arrow in the photo points to a cell in the prophase stage of mitosis. The chromosomes are becoming visible, the nucleolus has disappeared, and the nuclear envelope has broken down. These events, along with the assembling of a spindle apparatus, not visible in this photo, mark the prophase stage of mitosis. Label diagram 2, (c) chromosome, (d) nucleolus, and (e) nuclear envelope.</p>	<p>The arrow in the photograph points to a cell in metaphase. The chromosomes are attached to the microtubules of the spindle, and they are lined up across the equator of the cell in a circle that is perpendicular to cell's long axis. At this time it is possible to see, using higher magnification, that each chromosome consists of two chromatids. Remember that the chromatids were formed during interphase when replication occurred. Label F and the arrow point to the region of the spindle. It is lighter in shade than the rest of the surrounding cytoplasm. Finish labeling diagram 3.</p>	<p>In the photograph, arrows point to two anaphase stage cells. In both cells sister chromatids, now individual chromosomes, have separated from one another. Their separation is caused by the removal of microtubular units at the polar ends of the fiber to which the chromosomes are attached. This process shortens the fiber and draws the chromosome ever closer to the pole. Label diagram 4.</p>	<p>The arrows point to two cells beginning the telophase stage of mitosis. During this stage the spindle is disassembled, and the nuclear envelope reforms around each set of chromosomes. The chromosomes also begin to uncoil during this phase, and soon they take on a more thread-like appearance. Telophase completes the process of mitosis. Label diagram 5.</p>	<p>Note that the daughter cells indicated by the arrows are approximately one half the size of the original cell. Note also that the nuclear envelope is present again and the individual chromosomes are no longer visible. Also there is some evidence of nucleoli within the nuclear region. This indicates rRNA synthesis is underway. The partition dividing the new cells is still incomplete, but in time cellulose will be laid down to form a complete wall. The new cells now enter the interphase stage and start their period of rapid growth and begin to prepare for their next division.</p>

					
<p>These cells have been stained using a different dye. Notice that many of the cells are in the interphase stage as they show a distinct nuclear region with nucleoli. <u>Label your drawing (1) of the interphase cell and then begin labeling drawing 2.</u></p>	<p>The arrows point to two cells in prophase. The chromosomes are just becoming visible in this microscope photograph taken at a magnification of 1000X. The change in the chromosome from being thread-like and invisible is the result of the process of condensation where the chromosome coils and becomes very thick and compact. The growing but unfinished spindle apparatus being constructed at this time is not visible.</p>	<p>Metaphase ends as the chromatids of each chromosome begin their separation and start their migration to the opposite poles of the cell. The upper arrow points to the region of the spindle apparatus. The lower arrow points to the cell at metaphase. Label diagram 3 and then begin labeling drawing 4.</p>	<p>In this anaphase photograph, the separating sets of chromosomes are reaching the opposite poles of the cell. The genetic information in each set of chromosomes is identical as each set contains replicated “carbon copies” of the original set present in the cell at the start of interphase.</p>	<p>This cell, at the end of telophase, is beginning to assemble a cell plate that will eventually cut across the cell and partition the cytoplasm. The cell plate appears as a thin blue line midway between the groups of chromosomes in the photo. The assembly of the cell plate also produces two daughter cells (6). Label the cell plate (G).</p>	

Name: _____

Date: _____

Period: _____

Challenge Activity – Onion Root Tip Experiment (3.3)

1. Learn about cell division by working through the interactive tutorial on mitosis (http://biologyinmotion.com/cell_division/index.html).
2. Learn about cell division in onion root tips.
[Online onion root tips - p. 1](#)
[Online onion root tips - p. 2](#) description
[Online onion root tips - p. 3](#) determining time spent in different phases of the cell cycle

Materials

- Onion
- Container of water
- Microscope slides
- Toluidine blue
- Compound microscope
- Paper towel

Procedure

1. Set the bottom part of an onion in water. Leave it there for about 4 to 5 days, until the roots begin to grow.
2. When the roots are about 2 cm long, with active growth, cut several millimeters of some of the roots off.
3. Place the roots on a microscope slide; cut them lengthwise.
4. Press another slide down on the roots to mash them, and then remove the top slide.
5. Add some nuclear stain such as toluidine blue.
6. To stop the cell division and to quicken the stain, warm the slide over a flame for a few seconds, without allowing the liquid to boil.
7. Add a few more drops of stain, and let the sample sit for a few minutes.
8. After a few minutes, blot the stain with a paper towel.
9. Add a few drops of water, and put a coverslip on it.
10. Observe with a microscope. Look for the various stages of cell division.

	Interphase	Prophase	Metaphase	Anaphase	Telophase	Total
# of cells						
% of cells						

Name: _____

Date: _____

Period: _____

Mississippi MCT Biology Sample Questions (3.4)

Biology State Test Questions Related to PS.3.1a

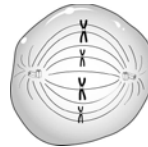
Highlights are the correct answers.

54. Meiosis is different from mitosis because meiosis produces:

- A. consistent genetic makeup of all gametes.
- B. larger daughter cells.
- C. two gametes for every original parent cell.
- D. cells with half the number of chromosomes.

57. What phase of mitosis is represented by the diagram shown above?

- A. Metaphase
- B. Prophase
- C. Telophase
- D. Interphase



63. Unlike mitosis, meiosis occurs only in:

- A. reproductive cells.
- B. muscle cells.
- C. connective tissue cells.
- D. nerve cells.

24. Sexual reproduction in plants depends on sex cells being produced by the process of:

- A. osmosis.
- B. fermentation.
- C. transpiration.
- D. meiosis.

37. Meiosis results in greater genetic variation than asexual reproduction because it:

- A. is a lengthy process full of errors.
- B. results in a greater number of offspring.
- C. is more common in higher order species.
- D. allows the recombination of genetic information.

Name: _____

Date: _____

Period: _____

Plant Nutrient PowerPoint Presentation (3.7)

Worth 100 points

	Points Worth	Points Obtained
Slide Creation		
• Title slide	5	
• Introduction slide (identify if macro/micro; elemental symbol)	5	
• Function in the Plant slide with pH reference	10	
• Deficiencies/Excess explanation with Illustration	10	
• Summary (no new information presented)	10	
• Reference Page	5	
Slide Format		
Bulleted list instead of paragraphs on slides	10	
Text Format/Capitalization Consistency (i.e., titles, bullets)	10	
Transition and Effect	5	
Presentation of Information		
• Voice Projection	10	
• Posture	5	
• Eye Contact with Audience	5	
• Familiar with Content	5	
• Answers to questions	5	
Subtotal		
Minus 2 points for each misspelled word		
Minus 5 points for presentation over 5 minutes NOT including questions		
Total		

- Each slide should have "Title Case."
- Bulleted list should have consistency in formatting with no more than six bullets/slide.
- Summary never contains "new information."
- Reference page should include where it came from (i.e., organization), not just the Web address.
- Presentation should be no longer than 5 minutes that does not include answers to questions.

Name: _____

Date: _____

Period: _____

Nutrient Deficiencies and Excesses Experiment (3.8)

Daily Observation Table

Treatment	Replication	Plant Height	Vigor Rating	Comments
Fertilizer Type	T-I			
	T-II			
Control Group	C-1			
	C-2			

Follow-Up Observations

Follow-up Observation and Summary

Treatment	Replication	Average Plant Height	Average Vigor Rating	Comments on color, deficiencies, excesses, etc.
Fertilizer Type	T-I			
	T-II			
Control Group	C-1			
	C-2			

Major Findings, Summary, and Recommendations: (Note to Instructor: Tables can be tailored to fit the experimental design. Students should record procedures and summarize results. Instructor can provide examples of findings, summary, and recommendations.)

Name: _____

Date: _____

Period: _____

Daily Participation Checklist (3.9)

CATEGORY	90–100 points/day	80–89 points/day	70–79 points/day	60–69 points/day	0–59 points/day
Attitude	Consistently positive attitude	Mostly positive attitude	Somewhat positive attitude	Neutral attitude	Somewhat to totally negative attitude
Pride	Work reflected the best the student could offer.	Work reflected a strong effort.	Work reflected some effort.	Work reflected very little effort.	No effort and no work
Focus on the Task	Student consistently focused on task or topic.	Student focused on task or topic most of the time.	Student focused on the task or topic some of the time.	Student paid little attention to the task or topic.	Student did not focus on the assigned task or topic.
Participation	Student consistently participated in an appropriate manner.	Student participated most of the time.	Student participated some of the time.	Student participated occasionally.	Student refused to participate.

Name: _____

Date: _____

Period: _____

Soil Test Report Summary (3.10)

Directions: Put your name on the top line, and fill in information under each column about the soil sample you brought in. Do the same for your group and each classmate.

Student Name	Soil Sample Site	Soil Type	Soil pH	Nutrient Content (if taken)			Recommendations
				N	P	K	

The purpose of this table is to compile **all** soil sample information. Students should write down their results and their group test results and other classmate test results.

Name: _____

Date: _____

Period: _____

Fertilizer Calculation Worksheet (3.11)

For each of the following situations, calculate the total amount of fertilizer that should be applied. You may use a calculator, but show all calculations in the space below each situation. (Round your answer to the nearest whole pound.)

1. A soil test reports that you should apply 60 lb of active nitrogen per acre to a corn field. If you are planning on using ammonium nitrate which is 34% N, how many pounds of this material would you apply on one acre?

2. Ammonium phosphate is a fertilizer material with an analysis of 18-46-0. If a soil test calls for application of 50 lb of active phosphate per acre, how many pounds of this material would you apply to a 120-acre pasture?

3. A soil test for a lawn calls for the application of $1 \frac{1}{2}$ lb of active nitrogen per 1,000 sq ft. If calcium nitrate contains 15% active N, how many pounds will be needed for a lawn that is 7,000 sq ft?

4. A soil test shows that a lawn is deficient in nitrogen and phosphate. If the test recommends that at least 1 lb of nitrogen and 2.5 lb of phosphate be applied to every 1,000 sq ft of lawn and if ammonium phosphate is rated as an 18-46-0 fertilizer, how many pounds of ammonium phosphate would you apply to a 10,000 sq ft lawn to make sure you applied enough nitrogen? At this rate, how many pounds of phosphate would you also be applying?

ANSWER SHEET FOR FERTILIZER CALCULATION WORKSHEET

1. 1 pound ammonium nitrate = 0.34 lb active nitrogen

$60 \text{ lb active nitrogen} \div 0.34 \text{ lb active nitrogen/1 lb ammonium nitrate} = 176 \text{ lb ammonium nitrate per acre}$

2. 1 lb ammonium phosphate = 0.46 lb active phosphate

$50 \text{ lb active phosphate} \div 0.46 \text{ lb active phosphate/1 lb ammonium phosphate} = 109 \text{ lb ammonium phosphate per acre}$

$109 \text{ lb per acre} \times 120 \text{ acres} = 13,080 \text{ lb}$

3. 1 lb calcium nitrate = 0.15 lb active nitrogen

$1 \frac{1}{2} \text{ lb active nitrogen} \div 0.15 \text{ lb active nitrogen/1 lb calcium nitrate} = 10 \text{ lb calcium nitrate per 1,000 sq ft}$

$10 \text{ lb/1,000 sq ft} \times 7,000 \text{ sq ft} = 70 \text{ lb of calcium nitrate}$

4. 1 lb ammonium phosphate = 0.18 lb active nitrogen and 0.46 lb active phosphate

$1 \text{ lb active nitrogen} \div 0.18 \text{ lb active nitrogen/1 lb ammonium phosphate} = 6 \text{ lb ammonium phosphate per 1,000 sq ft}$

$6 \text{ lb/1,000 sq ft} \times 10,000 \text{ sq ft} = 60 \text{ lb}$

$6 \text{ lb ammonium phosphate} \times 0.46 \text{ lb active phosphate per 1 lb ammonium phosphate} = 3 \text{ lb active phosphate}$

Name: _____

Date: _____

Period: _____

Questions for Unit Test (3.12)

Plant Growth and Nutrition Unit Test

Highlights are the correct answers.

Directions: Circle T if the statement is correct and F if the statement is false (5 pts ea).

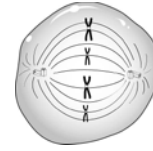
	True	False	Question
1	T	F	The tendrils of a muscadine vine are an example of phototropism.
2	T	F	Phototropism is caused by a plant hormone called auxin.
3	T	F	Plant growth stimulants are different from fertilizers.
4	T	F	Growth retardants help growers produce taller plants.
5	T	F	Blossom Buster (10-45-15) is high as potassium.
6	T	F	Nitrogen deficiency will cause a plant to have red spots on leaves.
7	T	F	There are 16 macronutrients.
8	T	F	Soil pH has no effect on plant nutrient availability.
9	T	F	Applications of lime will increase the pH of a soil.
10	T	F	The chemical formula for limestone is CaCO_3 .

Directions: Multiple Choice. Circle the best answer for each question (5 pts each). Questions 1, 2, 3, and 4 can be found on Biology State Sample Items.

- Meiosis is different from mitosis because meiosis produces:
 - genetic variation.
 - cells with half the number of chromosomes.
 - roots, stems, leaves, and flower parts.
 - both a and b.
- Unlike mitosis, meiosis occurs only in:
 - reproductive cells.
 - muscle cells.
 - connective tissue cells.
 - nerve cells.
- Sexual reproduction in plants depends on sex cells being produced by the process of:
 - osmosis.
 - fermentation.
 - transpiration.
 - meiosis.

4. What phase of mitosis is represented by the diagram show?

- a. Metaphase
- b. Prophase
- c. Telophase
- d. Interphase



5. Meiosis results in greater genetic variation than asexual reproduction because it:

- a. is a lengthy process full of errors.
- b. results in a greater number of offspring.
- c. is more common in higher order species.
- d. allows the recombination of genetic information.

6. The key nutrient that gives plants a rich green color is:

- a. nitrogen.
- b. phosphorous.
- c. potassium.
- d. calcium.

7. Nitrogen deficiency symptom causes a condition in the plant called:

- a. Tropism.
- b. etiolation.
- c. elongation.
- d. chlorosis.

8. How much nitrogen is in a 50-lb bag of 10-6-4 fertilizer? (Taken from AgScience textbook, 2002, p. 472)

- a. 5
- b. 6.5
- c. 8.5
- d. 13

9. How many pounds of 10-6-4 fertilizer must be used to apply 1 lb of nitrogen per 1,000 sq ft on a lawn that measures 5,000 sq ft?

- a. 25
- b. 50
- c. 75
- d. 100

10. CaCO_3 is the chemical formula for:

- a. gypsum.
- b. calcium sulfate.
- c. calcium carbonate.
- d. calcium chloride.

Name: _____

Date: _____

Period: _____

Classification Poster Rubric (4.1)

I Got This √	Poster Content	What It Is Worth	Points Obtained
	Common name of plant	10	
	One statistic about your plant	20	
	Classification (Family, genus, specie, and variety)	20	
	Description of native status (use more than one source if necessary)	10	
	Image of plant	20	
	Distribution in US and/or internationally (picture or text)	20	
	Quality Indicators		
	Quality of information <ul style="list-style-type: none">• Poster provides accurate information and demonstrates complete understanding. (40)• Poster provides accurate information and demonstrates partial understanding. (20)• Poster contains inaccurate information and/or demonstrates limited understanding. (10)	40	
	Demonstration of understanding <ul style="list-style-type: none">• Poster is very clear and easy to comprehend. (20)• Poster is cluttered but comprehensible. (15)• Poster is not easy to read or understand. (10)	20	
	Production quality <ul style="list-style-type: none">• Poster is creative and original. (20)• Poster shows some creativity. (15)• Poster shows little creativity and originality. (10)	20	
	Overall Appeal		

Name: _____

Date: _____

Period: _____

Daily Participation Rubric (4.2)

CATEGORY	90–100 points/day	80–89 points/day	70–79 points/day	60–69 points/day	0–59 points/day
Attitude	Consistently positive attitude	Mostly positive attitude	Somewhat positive attitude	Neutral attitude	Somewhat to totally negative attitude
Pride	Work reflected the best the student could offer.	Work reflected a strong effort.	Work reflected some effort.	Work reflected very little effort.	No effort and no work
Focus on the Task	Student consistently focused on task or topic.	Student focused on task or topic most of the time.	Student focused on the task or topic some of the time.	Student paid little attention to the task or topic.	Student did not focus on the assigned task or topic.
Participation	Student consistently participated in an appropriate manner.	Student participated most of the time.	Student participated some of the time.	Student participated occasionally.	Student refused to participate.

Name: _____

Date: _____

Period: _____

Annual, Biennial, or Perennial (4.3)

Classify each of the following common plants are either an annual (A), a biennial (B), or a perennial (P).

_____ Parsley

_____ Corn

_____ Cotton

_____ Asparagus

_____ Roses

_____ Carrots

_____ Magnolia

_____ Daffodils

_____ Marigold

_____ Pansy

_____ Iris

_____ Soybean

_____ Lettuce

_____ Lima Bean

_____ Dandelion

Name: _____

Date: _____

Period: _____

Stems, Roots, and Flowers Booklet Rubric (4.4)

I Got This	Booklet Contents	What It Is Worth	Points Obtained
	Title page with illustration and name	10	
	Stem illustrations On page 2 of the booklet, draw and briefly describe the following: <ul style="list-style-type: none">• Bulb (Fig. 15-8) and description	10	
	<ul style="list-style-type: none">• Corm (Fig. 15-9) with description	10	
	<ul style="list-style-type: none">• Rhizomes (15-10) with description	10	
	<ul style="list-style-type: none">• Tuber (Fig. 15-11) with description	10	
	On page 3, draw and label part of stems (Fig. 15-7).	20	
	Total for Stem Section	60	
	Root illustrations On page 4 of the booklet, draw and briefly describe the following: <ul style="list-style-type: none">• Adventitious roots (Fig. 15-2) and description	10	
	<ul style="list-style-type: none">• Fibrous roots (Fig. 15-4) and description	10	
	<ul style="list-style-type: none">• Taproot (Fig. 15-5) and description	10	
	On page 5 of the booklet, draw and label root structure (Fig. 15-6).	20	
	Total for Root Section of Booklet	50	
	On page 5 of the booklet, draw and label a cross section of an apple.	10	
	On page 6 of the booklet, draw (8 pts) and label (22 pts) parts of a flower.	30	
	Total for Flower Section of Booklet	40	
	Drawings are colored.	20	
	Labeling is neat and readable.	10	
	Descriptions are neat and readable.	10	
	Total for Points for Neatness and Readability	40	
	TOTAL POINTS OBTAINED		

Figures referenced in this assignment can be found in the textbook, Unit 15 (Burton & Cooper, 2007).

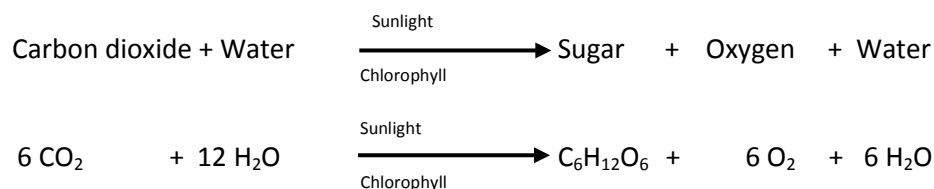
Name: _____

Date: _____

Period: _____

Photosynthesis, Respiration, and Transpiration Information Sheet (4.5)

An important life process is carried out in plants by the chloroplasts, small green bodies present in the cells of green leaves. This process is called photosynthesis. Photosynthesis is the process by which water (H₂O), carbon dioxide (CO₂), and light energy are changed into a sugar (C₆H₁₂O₆) and oxygen (O₂) as shown in the following chemical reaction:



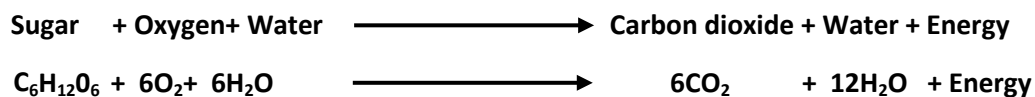
The water needed for photosynthesis is picked up by the roots. It travels upward through the stem to the leaves. The carbon dioxide gas needed for photosynthesis gets into the leaf cells through tiny openings (stomata) in the leaf.

Within the chloroplasts is a green substance called chlorophyll. The chlorophyll absorbs, or picks up, light energy. Then the light energy causes a change to take place. This change involves water and carbon dioxide. The result of this change is that a sugar and oxygen are produced. The plant uses the sugar for food. The oxygen is given off into the air through the openings in the leaf.

Not all of the food that a plant makes during photosynthesis is used right away. Some of the food is stored. This stored food is mostly used by the plant during the night for its life activities.

The process by which a plant uses the stored food is called respiration. Respiration is a kind of burning process and is the opposite of photosynthesis. Photosynthesis stores energy. Respiration releases energy. Photosynthesis and respiration are different in one other important way. Only cells with chlorophyll can carry on photosynthesis. However, all cells carry on respiration.

During respiration, oxygen is taken in through the openings in the leaf. The plant cells use the oxygen to help break down the stored food into energy. The plant uses the energy for life activities. This breakdown also produces water and carbon dioxide, which the plant gives off through the openings in the leaf. The following chemical reaction illustrates this process.



Much of the water a plant takes in is lost through transpiration. Transpiration is the loss of water through a plant's stomates. During the day, while a plant makes food, the stomates are open. These tiny openings in a leaf are controlled by special cells called guard cells, which are located on each side of the

opening. When the guard cells are full of water, the opening is open. When the guard cells are not full, the opening is closed or nearly closed. As water flows up to the leaves, most of it is lost through the stomates. The loss of water helps keep leaves cool during the day. This loss also helps pull water up through a plant. As water evaporates through the stomates, more water moves up and replaces the water that is lost.

RESPIRATION

Before cells can carry out respiration, they must first have food. How do plants get the food oxygen needed for respiration? How do cells change sugar to energy?

1. Sugar is made in the leaf.
2. It is carried by the veins in the leaf to the stem. Food-carrying tubes in the stem transport sugar to all parts of the stem and down to the roots.
3. The oxygen combines with sugar in the cell.
4. When oxygen and sugar combine, energy is released. The energy is used by the cell to carry out life processes.
5. Carbon dioxide and water are given off as waste products.

Comparison table for photosynthesis and respiration

The process of respiration is the opposite of the process of photosynthesis. Complete the table below to show differences in the two processes.

Photosynthesis	Respiration
Takes place only in cells with chlorophyll	
	Sugar is broken down.
Energy from the sun is stored.	
	Carbon dioxide is produced.
Water is taken in.	
	Oxygen is used.

Name: _____
 Date: _____
 Period: _____

Transpiration Activity (4.6)

Did you know that plants are an important part of the water cycle? In this activity, you are going to learn how plants are part of the water cycle by collecting water vapor from the leaves of plants.

Directions

1. Carefully slide a large, plastic bag over a branch or stem of a plant containing at least three or four healthy green leaves that are dry on the surface. Attach the bag around the stem with a clothespin. Best results will occur on a warm day if there is a good amount of sunlight available (not overcast). Observe the bag after 20–30 minutes.
2. On the data table below, write down the date and type of tree or other plant, if known (e.g., maple, oak, dogwood). Draw a picture of one of your leaves. You can compare your results with another group in you class who may select another type of tree.
3. After 30–40 minutes, check your leaves to see if you collected any moisture. (You may check again later in the day.) Write down your observations. You may also take digital photo of your plant to record the amount of moisture in the bag.
4. You may be able to collect enough water to measure the amount (volume) in milliliters using a graduated cylinder. To do this, collect the water in the plastic bag using an eyedropper, and transfer to the graduated cylinder. Record your results on the data table.

Transpiration Data Sheet

Name _____

Date:	Type of Plant:	Amount of Water Collected: _____ ml
Drawing of Leaf: Number of leaves in bag:		My Observations:

Questions

1. Where do you think the water in the plastic bags came from?

2. If the bag had not been placed over the plant, where would the water that you observed have gone?

3. Is there a connection between the water that transpires from plant leaves and the water that falls to earth from clouds (rain and snow)?

4. How do your results compare with your classmates' (who may have collected water in other types of plants)? Be sure to think about the size of the leaves.

5. Why do you think trees are an important part of keeping rainforests rainy?

Name: _____

Date: _____

Period: _____

Plant Classification and Physiology Unit Test (4.7)

Directions: Circle T if the statement is correct and F if the statement is false (5 pts each).

Highlights are the correct answers.

	True	False	Question
1	T	F	A perennial completes its life cycle in 1 year.
2	T	F	Transpiration takes place in the stomata of the leaves.
3	T	F	A carrot has a fibrous root system.
4	T	F	The apical meristem is the least actively growing part of a plant.
5	T	F	Respiration occurs in all cells.
6	T	F	As xylem tubes die they forms tree rings.
7	T	F	Dripping sap usually comes from the phloem.
8	T	F	A potato is a specialized stem called a bulb.
9	T	F	Plant varieties develop in nature.
10	T	F	Pecan leaves are considered simple leaves.

Directions: Multiple Choice. Circle the *best answer* for each question. (5 pts each)

- Which of these scientific classification groups has the fewest members?
 - Class
 - Genus
 - Species
 - Family
- The scientific name for bay live oaks that grow along the coast is *Quercus virginiana* var. *maritima* (Mill). Which of the following is MOST closely related to bay live oaks?
 - Batis maritime*
 - Carpinus carolina* var. *virginiana*
 - Clematis virginiana* L.
 - Quercus falcata* var. *pagodaefolia* (Ell.)
- Two plants probably belong to the same species if they:
 - have leaves that look alike.
 - can produce fertile offspring.
 - have the same number of cotyledons.
 - develop the same type of chlorophyll.
- The red maple tree is known by the scientific name *Acer rubrum*. The sugar maple tree is known as *Acer saccharum*. What is the smallest classification division these trees have in common?
 - Phylum
 - Order
 - Genus
 - Species

5. Oxygen is added to an ecosystem by:
 - a. cellular respiration.
 - b. photosynthesis.
 - c. the nitrogen cycle.
 - d. dehydration.
6. During photosynthesis, energy from the sun is trapped in:
 - a. chemical bonds.
 - b. the nuclei of atoms.
 - c. enzymes.
 - d. Golgi bodies.
7. The process of photosynthesis produces sugar, water, and:
 - a. hydrogen gas.
 - b. nitrogen dioxide gas.
 - c. carbon dioxide gas.
 - d. oxygen gas.
8. Because most plants are able to undergo photosynthesis, they do NOT:
 - a. require carbon dioxide.
 - b. store energy for later use.
 - c. undergo cellular respiration.
 - d. depend on other organisms for energy.
9. What are the end products of photosynthesis?
 - a. Oxygen and sugar
 - b. Carbon dioxide and water
 - c. Glucose and carbohydrates
 - d. Xylem and Phloem
10. What are the reactants for photosynthesis?
 - a. Oxygen and sugar
 - b. Carbon dioxide and water
 - c. Glucose and carbohydrates
 - d. Xylem and Phloem
11. What are the end products of cellular respiration?
 - a. Oxygen and sugar
 - b. Carbon dioxide and water
 - c. Glucose and carbohydrates
 - d. Xylem and Phloem
12. What is the primary light-gathering pigment in plants?
 - a. Chlorophyll
 - b. Chloroplast
 - c. Carotenoids
 - d. Mitochondria
13. Where is the chlorophyll found?
 - a. Chromatids
 - b. Chloroplast
 - c. Carotenoids
 - d. Mitochondria

14. Where does transpiration occur in plant leaf cells?
- a. Stomata
 - b. Vacuole
 - c. Stroma
 - d. Cell wall
15. The collective term for all female flower parts is called:
- a. stigma.
 - b. style.
 - c. stamen
 - d. pistil.

Name: _____

Date: _____

Period: _____

Bedding Plant Keyword Exercise (4.8)

Directions: Read the following paragraph, underline keywords already learned in Plant Science, and be prepared to discuss their meaning.

Hundreds of different annuals, perennials, herbs, and vegetable transplants can be grown and sold as bedding plants. A single commercial greenhouse business may produce as many as 500 different kinds of bedding plants in the spring. Some of the most popular bedding plants include: impatiens, petunias, geraniums, pansies, begonias, and marigolds. Tomatoes, peppers, and cole crops are popular vegetable transplants.

Enter the total cost of production below. (If you used school materials, have your teacher provide you with an estimated cost.)

Containers
Media
Fertilizer
Pest Control
Other Costs
TOTAL COSTS

How many plants did you produce?

What was the average cost per plant?

Name: _____
Date: _____
Period: _____

Mendel's Law and Punnet Squares (5.1)

Gregor Mendel and the Basics of Genetics

When most people think of genetics, they think of a modern, high-tech science, with people in lab coats doing strange things to cells. What they do not realize is that the science of genetics was invented by a 19th Century monk who enjoyed a spot of gardening.

Gregor Mendel was born in 1822 in what is now the Czech Republic, the son of poor peasant farmers. Although he did well at school, his parents could not afford to send him to university, so he went instead to the Augustinian monastery at Brunn¹. After studying there for some time, he moved to the University of Vienna in Austria to study science and mathematics. After failing his exams for a teaching degree, Mendel returned to the monastery where he became Abbot and spent the rest of his life.

Mendel's Garden

The monastery at Brunn was blessed with large and beautiful gardens, and Mendel was a keen gardener. It was during his work in the garden that he began to take a close interest in garden peas. He noticed that peas had certain characteristics that seemed to be passed from generation to generation. For example, plants with peas that were green had offspring with green peas, while those with yellow peas produced yellow offspring. Over seven years, Mendel carried out an enormous number of experiments with these plants, studying characteristics such as height, seed shape, seed colour and flower colour. Despite knowing nothing about DNA² or the biochemistry of inheritance, Mendel developed his two 'Laws of Heredity', which remain the basis of modern genetics.

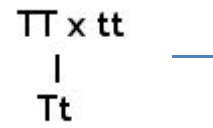
Big Plants and Little Plants

Mendel's experiments relied on studying pairs of characteristics that seemed to be 'either-or' in the plants. For example, the garden had tall pea plants and short pea plants, but no in-between ones. So, Mendel decided to cross a tall plant with a short plant and measure the result. To his surprise, all the offspring were tall, rather than the intermediate size that might have been expected. Continuing the experiment, he crossed the new tall plants with each other. In the next generation, three-quarters of the plants were tall, but one-quarter were short. In summary:

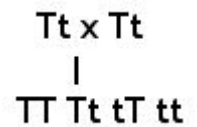
Tall x Short
|
Tall
/ \
Tall x Tall
|
3 Tall + 1 Short

These results were repeated with whatever pair of characteristics Mendel chose. Yellow seeds crossed with green seeds produced all yellow seeds. If the new yellow seeds were crossed with each other, three-quarters were yellow and one-quarter were green.

From these simple experiments, Mendel theorized that these characteristics must be inherited as 'particles' of some sort - what we now know as 'genes'. Each plant had two genes for each characteristic. If the gene for tallness is shown with a capital T and the gene for 'shortness' by a lower-case t, then each plant could be either TT (pure-bred tall), tt (pure-bred short) or Tt. These Tt plants were tall because the T gene is 'dominant' to the t gene, which is referred to as 'recessive'³:



In Mendel's original experiment, each offspring plant must have inherited a T gene from the tall parent and a t gene from the short parent - no other combinations are possible. At this stage in his experiments, however, Mendel did not know for certain that each offspring inherited one gene from each parent. It was confirmed when Mendel crossed the new Tt plants, and this happened:



It can be seen that three-quarters of the plants will be tall, having either TT or Tt genes, while the remaining quarter have inherited the 'recessive' short gene from both parents and will therefore be short. This is precisely what happened in the real experiment, and the separation of the pairs of genes during reproduction became Mendel's First Law.

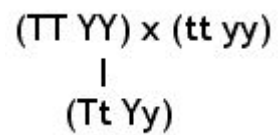
Having covered the concepts of dominance and recessivity, this seems like a good time for a quick...

Try This At Home

To see Mendel's first law in action, try rolling your tongue (i.e., curling your tongue into a tube). Then ask your parents, siblings, children, aunts, uncles, cousins and grandparents if they can do it. Tongue rolling is an action controlled by a single gene with two alleles. Those who can do it have at least one dominant 'R' gene, while those who can't have two recessive 'r' genes.

Big Yellow Plants and Little Green Plants

In Mendel's second set of experiments, he looked at two pairs of characteristics together. For example, he took tall plants that produced yellow seeds (both dominant characteristics) and crossed them with short plants producing green seeds (both recessive characteristics). Using 'Y' to represent the 'yellow' allele and 'y' to represent the 'green' allele, the results looked something like this:



So, a parent that is (Tt Yy) can produce four different gametes: Have students draw the following table in their notebook and fill in blanks for genetic combinations and discuss results.

		Y	y		Key		Y	y	
	T					T	TY	Ty	
	t					t	tY	ty	

Then, when two (Tt Yy) parents mate, there are 16 possible combinations in the offspring. Have students draw the following table in their notebook and fill in blanks for genetic combination and discuss results.

<table border="1" style="width: 100%; text-align: center;"> <tr><td></td><td>TY</td><td>Ty</td><td>tY</td><td>ty</td></tr> <tr><td>TY</td><td></td><td></td><td></td><td></td></tr> <tr><td>Ty</td><td></td><td></td><td></td><td></td></tr> <tr><td>tY</td><td></td><td></td><td></td><td></td></tr> <tr><td>ty</td><td></td><td></td><td></td><td></td></tr> </table>		TY	Ty	tY	ty	TY					Ty					tY					ty					<p>Key</p> <table border="1" style="width: 100%; text-align: center;"> <tr><td></td><td>TY</td><td>Ty</td><td>tY</td><td>ty</td></tr> <tr><td>TY</td><td>TT YY</td><td>TT Yy</td><td>Tt YY</td><td>Tt Yy</td></tr> <tr><td>Ty</td><td>TT yY</td><td>TT yy</td><td>Tt yY</td><td>Tt yy</td></tr> <tr><td>tY</td><td>tT YY</td><td>tT Yy</td><td>tt YY</td><td>tt Yy</td></tr> <tr><td>ty</td><td>Tt Yy</td><td>tT yy</td><td>tt yY</td><td>tt yy</td></tr> </table>		TY	Ty	tY	ty	TY	TT YY	TT Yy	Tt YY	Tt Yy	Ty	TT yY	TT yy	Tt yY	Tt yy	tY	tT YY	tT Yy	tt YY	tt Yy	ty	Tt Yy	tT yy	tt yY	tt yy
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<table border="1" style="width: 100%;"> <tr> <td style="width: 30%; text-align: center;">Tall, yellow seeds</td> <td style="width: 10%; text-align: center;">9/16</td> <td style="width: 60%;"> TT YY TT Yy TT yY Tt YY Tt Yy Tt yY tT YY tT Yy tT yY </td> </tr> <tr> <td style="text-align: center;">Tall, green seeds</td> <td style="text-align: center;">3/16</td> <td> TT yy Tt yy tT yy </td> </tr> <tr> <td style="text-align: center;">Short, yellow seeds</td> <td style="text-align: center;">3/16</td> <td> tt YY tt Yy tt yY </td> </tr> <tr> <td style="text-align: center;">Short, green seeds</td> <td style="text-align: center;">1/16</td> <td>tt yy</td> </tr> </table>	Tall, yellow seeds	9/16	TT YY TT Yy TT yY Tt YY Tt Yy Tt yY tT YY tT Yy tT yY	Tall, green seeds	3/16	TT yy Tt yy tT yy	Short, yellow seeds	3/16	tt YY tt Yy tt yY	Short, green seeds	1/16	tt yy	<p>The table on the left could be also given with blank areas for students to fill out.</p> <p>Mendel's work allowed us to understand the concept of inheritance, leading to breakthroughs in fields as diverse as agriculture and medicine.</p>																																						
Tall, yellow seeds	9/16	TT YY TT Yy TT yY Tt YY Tt Yy Tt yY tT YY tT Yy tT yY																																																	
Tall, green seeds	3/16	TT yy Tt yy tT yy																																																	
Short, yellow seeds	3/16	tt YY tt Yy tt yY																																																	
Short, green seeds	1/16	tt yy																																																	

Reference: BBC-h2g2 (23rd December 2002). Gregor Mendel and the basics of genetics. Retrieved on June 15, 2010, from <http://www.bbc.co.uk/dna/h2g2/A885521>

Name: _____

Date: _____

Period: _____

Daily Participation Rubric (5.2)

CATEGORY	100 points/day	90 points/day	80 points/day	70 points/day	50 points/day
Attitude	I always have a positive attitude about the task(s).	I often have a positive attitude about the task(s).	I usually have a positive attitude about the task(s).	I often have a negative attitude about the task(s).	I refused to do the assigned task(s).
Pride	The work I did reflected my best effort.	The work I did reflected a strong effort.	My work reflected some effort.	My work reflected very little effort.	I refused to work on any assigned task.
Focus on the Task	I stayed focused on the task and what needed to be done.	I focused on the task and what needed to be done most of the time.	I focused on the task and what needed to be done some of the time.	I did not focus on the task and what needed to be done. I let others do the work.	I did not focus on any assigned task.
Cleanup	I helped make sure cleanup tasks were done to completion.	I helped do some of the cleanup task.	Cleanup task were done, but I did not participate.	The work space was left in a mess.	I refused to participate in cleanup.

Students will get up to 100 points/day for a possible total of 500 points for the week. A weekly average will be taken and posted on PARENT CONNECT for your viewing.

If a student is absent, he or she will be held responsible for making up any daily assignments and/or tasks they missed.

I have read and understand the above terms in which grades will be issued based on my daily participation in AEST class.

Student Signature

Date

Parent Signature

Date

Name: _____

Date: _____

Period: _____

DNA Structure Activity (5.3)

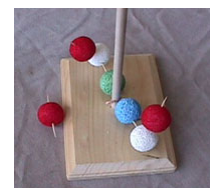
Material: To construct a DNA model, you will need the following material:

- Styrofoam balls (about 100)
- Double end toothpicks (75)
- Wooden or metal laboratory stand
- Brushes for painting the balls
- Additional material such as paint or water color, glue, string



You may purchase all the required material separately from different local stores or you may prefer to order a kit; however, you should know that kits do not come with paint and glue.

Instructions: Decide what colors you want to use for small molecules forming each large DNA molecule. The model shown above is based on colors suggested in the kit instructions; however, you may select any other colors for the balls. Paint all the balls, and let them dry. Depending on the paint, it may take up to 24 hr for paints to dry.



Start from the base, and connect the molecules to each other using toothpicks.

For the first row, make a pair of C-G (Cytosine-Guanine). Add the phosphates to the backbone, and then assemble the second row that again can be C-G or A-T (Adenine-Thymine). Continue the ladder until you run out of balls.

You may use the same balls as atoms to make models of models of different chemicals.

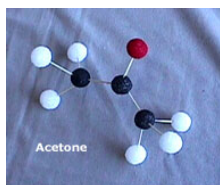
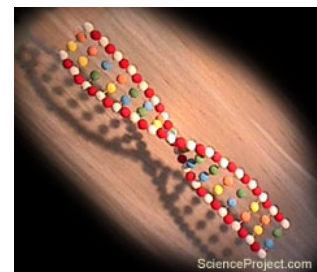
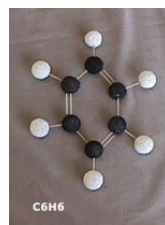


Image in the left shows a molecule of Acetone. White balls are hydrogen. Black balls are carbon; the red ball is oxygen (connected with two bonds). Image on the right is a molecule of benzene.



You can order a materials kit for DNA Model. In addition to the kit, you will need some water color or water-based paints to paint the balls.

Name: _____

Date: _____

Period: _____

Germination Test Experiment (5.4)

Seed Germination Data Sheet

Date turned in: _____

Names in group: _____

Type of seed: Acorn

Treatments	Date planted	# planted	Seed Coat Split Date	Temp when planted	Date germinated	# Germinated	% Germinated	Comments
Refrigerated								
Greenhouse								
Incubator								
Classroom								

Type of seed: Bean

Treatments	Date planted	# planted	Seed Coat Split Date	Temp when planted	Date germinated	# Germinated	% Germinated	Comments
Refrigerated								
Greenhouse								
Incubator								
Classroom								

Type of seed: Corn

Treatments	Date planted	# planted	Seed Coat Split Date	Temp when planted	Date germinated	# Germinated	% Germinated	Comments
Refrigerated								
Greenhouse								
Incubator								
Classroom								

SUMMARY OF RESULTS: (30 pts) Discussion should include everything you did (procedures).

- Students could be placed in groups.
- Media should be the same. Moist peat moss usually recommended
- Have one data sheet per group.
- Each piece of data in the chart could be worth 5 and summary worth 20 points.

Adapted from Dirr, M & Heuser, C. JR. (1987). *The reference manual of woody plant propagation. From see to tissue culture*. Varsity Press, Inc. Athens, GA. ISBN 0-942375-00-9

Name: _____

Date: _____

Period: _____

Rooting Hormone Experiment Data Collection Sheet (5.5)

Rooting Hormone Experiment						
Plant Type:						
Media Type:						
Names in Group:						
Treatments	ROOT RATINGS - After 1 Month					
	0	1	2	3	4	5
RH-Plant1						
RH-P2						
RH-P3						
No rooting hormone						
No-RH-P1						
No-RH-P2						
No-RH-P3						

Root ratings are based on a scale with 0 = Dead and 5 = Most Roots.

SUMMARY OF RESULTS:

Name: _____

Date: _____

Period: _____

Unit Test Questions (5.6) Highlights are the correct answers.

Directions: Circle T if the statement is correct and F if the statement is false (5 pts ea).

	True	False	Question
1	T	F	rDNA uses DNA molecules from two unrelated organisms to create superior offspring.
2	T	F	DNA is located in chromatins.
3	T	F	Seeds require light for germination.
4	T	F	Leaves of a monocot have parallel venations.
5	T	F	Explants are small pieces of plants used in tissue culture.

Directions: Multiple Choice. Circle the best answer for each question. (5 pts each)

1. What is the molecular chain that stores genetic information in all living cells?
 - a. Chromosomes
 - b. Nucleus
 - c. DNA**
 - d. Nuclear envelop
2. What profession involves genetic engineering of plants?
 - a. Biotechnology**
 - b. Entomology
 - c. Pathology
 - d. Toxicology
3. Seeds develop from what part of the flower?
 - a. Ovule**
 - b. Ovary
 - c. Sperm
 - d. Epicotyl
4. The process whereby a seed must go through a period of cold temperatures before it germinates is called:
 - a. stratification.**
 - b. scarification.
 - c. propagation.
 - d. dissemination.
5. What form of plant reproduction involves the combining of genetic material from two parents?
 - a. Sexual plant reproduction**
 - b. Asexual Plant Reproduction
 - c. Tissue Culture
 - d. Vegetative Cuttings

6. What part of the flower develops into the fruit?
 - a. Ovule
 - b. Ovary**
 - c. Sperm
 - d. Epicotyl
7. Seed leaves are called:
 - a. embryo.
 - b. cotyledon.**
 - c. epicotyl.
 - d. hypocotyl.
8. What type of asexual plant reproduction allows for thousands of identical plants produced from small pieces of plants?
 - a. Vegetative cuttings
 - b. Layering
 - c. Division
 - d. Tissue culture**

Complete the Punnett's square shown below using the following information. (T=tall, t=short, Y=yellow, y=green)

	TT	tt
YY		
yy		

Name: _____

Date: _____

Period: _____

Greenhouse Tour Activity (6.1)

Instructions:

Take a tour of the greenhouse. Use the chart below to provide students with the number and name of each station on the tour. Have students complete the chart as they participate in the tour. Note: Greenhouse control panel should be shown by instructor only.

Station Number	Station Name	Comments, Characteristics, Uses, etc.
1	QUONSET STYLE GREENHOUSE	
2	GREENHOUSE COVERING (POLYETHYLENE)	
3	COOLING FANS	
4	VENTS	
5	DOOR SIZE	
6	GREENHOUSE FLOOR COVERING (GRAVEL)	
7	INSIDE FANS	
8	THERMOSTAT	
9	HOSE (TALK ABOUT PRESSURE)	
10	HOSE USAGE AND PLACEMENT	
11	COOLING PADS	
12	SUMP PUMP	
13	TWO LAYERS POLY	
14	BLOWER MOTOR	
15	SHADE CLOTH	
16	THERMOMETER	

Name:
Date:
Period:

Structure and Control Systems Presentation and Rubric (6.2)

Assign a student or pair of students to research each of the following topics and prepare a PowerPoint presentation to be made to the entire class: even span greenhouses, Quonset greenhouses, ridge and furrow greenhouses, greenhouse coverings (fiberglass, polyethylene, polycarbonate, and shade cloths), heating systems and controls, cooling systems and controls, humidity indicators, and ventilation systems and controls.) All students should make a presentation as it will count for a grade. Presentations will be evaluated using the rubric on the following page.

Have students present their PowerPoint presentations to the class as a whole. After the presentations, have students ask questions and hold a class discussion to make sure that all important points are covered. Have students summarize the major points of each presentation and enter into their electronic journals or notebooks. Questions on the major points covered will be included on the unit test.

PowerPoint Presentation Criteria and Rubric

100 points

Topic: _____

Name: _____

Date: _____

	Points Worth	Points Obtained
Slide Creation (Three–six slides including reference page; all slides should contain pictures)		
• Title slide	5	
• Introduction slide with description and picture	5	
• Characteristics	10	
• Advantages/disadvantages/uses	10	
• Summary (no new information presented)	10	
• Reference page	5	
Slide format		
Bulleted list NOT PARAGRAPHS	10	
Text format/capitalization consistency(i.e., titles, bullets)	10	
Transition and effect	5	
Presentation of Information		
• Voice projection	10	
• Posture	5	
• Eye contact with audience	5	
• Familiar with content	5	
• Answers to questions	5	
	Subtotal	
Minus 2 points for each misspelled word and/or grammatical error		
Minus 5 points for presentation over 5 min NOT including questions		

Name: _____

Date: _____

Period: _____

Daily Participation Rubric (6.3)

CATEGORY	100 points/day	90 points/day	80 points/day	70 points/day	50 points/day
Attitude	I always have a positive attitude about the task(s).	I often have a positive attitude about the task(s).	I usually have a positive attitude about the task(s).	I often have a negative attitude about the task(s).	I refused to do the assigned task(s).
Pride	The work I did reflected my best effort.	The work I did reflected a strong effort.	My work reflected some effort.	My work reflected very little effort.	I refused to work on any assigned task.
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I have read and understand the above terms in which grades will be issued based on my daily participation in AEST class.

Student Name

Date

Parent/Guardian Name

Date

Name: _____

Date: _____

Period: _____

Plant Water Management Data Sheet (6.4)

Did you fertilize?		If yes, with what?	At what rate?
Y	N		

Plant Name	Location	Pot Size	Soil Condition	Pruned?	Plant Health Observations	Other Comments

Name: _____

Date: _____

Period: _____

Group Participation Rubric (7.1)

	Beginning	Developing	Accomplished	Exemplary	Score
	1 point	2 points	3 points	4 points	
Group Discussions	Rarely contributed to discussions of the group	Contributed good effort to discussions of the group	Contributed great effort to discussions of the group	Contributed exceptional effort to discussions of the group	
On-task Behavior	Exhibited on-task behavior inconsistently	Exhibited on-task behavior some of the time	Exhibited on-task behavior most of the time	Exhibited on-task behavior consistently	
Helping Others	Did not assist other group members	Seldom assisted other group members	Occasionally assisted other group members	Assisted other group members	
Listening	Ignored ideas of group members	Seldom listened to ideas of group members	Occasionally listened to ideas of group members	Always listened to ideas of group members	

Name: _____

Date: _____

Period: _____

Soil Data Summary Sheet (7.2)

Sample No.	Microscopic Evaluation			Ribbon Test	Textural Class
	% Sand	% Silt	% Clay	Description	
1					
2					
3					
4					
5					

Name: _____

Date: _____

Period: _____

Mississippi Land Judging Scorecard (7.3)

Part I (30 points)		Part II – Practices for Land Treatment (30 points)	
Score	A. SURFACE TEXTURE <input type="checkbox"/> 1. Medium <input type="checkbox"/> 2. Moderately fine <input type="checkbox"/> 3. Fine <input type="checkbox"/> 4. Moderately coarse <input type="checkbox"/> 5. Coarse	Score	VEGETATION PRACTICES Use soil conserving and improving crops. <input type="checkbox"/> 1. Every 4th or 5th year <input type="checkbox"/> 2. Every 3rd or 4th year <input type="checkbox"/> 3. Every 2nd year <input type="checkbox"/> 4. Do not burn crop residue. <input type="checkbox"/> 5. Crop residue management <input type="checkbox"/> 6. Establish recommended grasses and/or legumes. <input type="checkbox"/> 7. Proper pasture or range management <input type="checkbox"/> 8. Protect from burning. <input type="checkbox"/> 9. Control grazing. <input type="checkbox"/> 10. Control noxious plants. <input type="checkbox"/> 11. Plant recommended tree. <input type="checkbox"/> 12. Harvest trees selectively. <input type="checkbox"/> 13. Timber stand improvement <input type="checkbox"/> 14. Prevent forest fires. <input type="checkbox"/> 15. Build and/or maintain fire roads.
	B. PERMEABILITY <input type="checkbox"/> 1. Moderate <input type="checkbox"/> 2. Slow <input type="checkbox"/> 3. Very slow <input type="checkbox"/> 4. Rapid		
	C. DEPTH, SURFACE, + SUBSOIL <input type="checkbox"/> 1. Deep <input type="checkbox"/> 2. Moderately deep <input type="checkbox"/> 3. Shallow <input type="checkbox"/> 4. Very shallow		
	D. SLOPE <input type="checkbox"/> 1. Nearly level <input type="checkbox"/> 2. Gently sloping <input type="checkbox"/> 3. Moderately sloping <input type="checkbox"/> 4. Strongly sloping <input type="checkbox"/> 5. Steep <input type="checkbox"/> 6. Very steep		MECHANICAL PRACTICES <input type="checkbox"/> 16. Filter strips <input type="checkbox"/> 17. Terrace and farm on contour <input type="checkbox"/> 18. Construct and maintain diversion terraces. <input type="checkbox"/> 19. Install drainage system. <input type="checkbox"/> 20. Control gullies. <input type="checkbox"/> 21. Provide vegetative outlets. <input type="checkbox"/> 22. Fence <input type="checkbox"/> 23. Provide stock water.
	E. EROSION <input type="checkbox"/> 1. None to slight <input type="checkbox"/> 2. Moderate <input type="checkbox"/> 3. Severe <input type="checkbox"/> 4. Very severe		FERTILIZER & SOIL AMENDMENTS <input type="checkbox"/> 24. Lime <input type="checkbox"/> 25. Animal by-product/compost <input type="checkbox"/> 26. Nitrogen <input type="checkbox"/> 27. Phosphate <input type="checkbox"/> 28. Potash <input type="checkbox"/> 29. Nitrogen, phosphate, and potash <input type="checkbox"/> 30. No fertilizers or soil amendments needed
	F. SURFACE RUNOFF <input type="checkbox"/> 1. Good <input type="checkbox"/> 2. Fair <input type="checkbox"/> 3. Poor <input type="checkbox"/> 4. Excessive		
	G. FACTORS THAT KEPT LAND FROM BEING CLASS I <input type="checkbox"/> 1. Texture <input type="checkbox"/> 2. Permeability <input type="checkbox"/> 3. Depth <input type="checkbox"/> 4. Slope <input type="checkbox"/> 5. Erosion <input type="checkbox"/> 6. Surface runoff		Score Part I _____ (Possible 30 points)
	H. LAND CAPABILITY CLASS (Circle your choice) 1 2 3 4 5 6 7 8		Score Part II _____ (Possible 30 points)
	I. HIGHEST LAND USE (Check one) <input type="checkbox"/> 1. Row crops <input type="checkbox"/> 2. Pasture <input type="checkbox"/> 3. Woodland		Total Score _____ (Possible 30 points)

Name: _____

Date: _____

Period: _____

Hydroponics Booklet Rubric (7.4)

I Got This	Booklet Contents	What It Is Worth	Points Obtained
	Title page with illustration and name	5	
	Hydroponics system drawings		
	On pages 2 and 3 of the booklet, draw, label, and briefly describe a continuous flow system.	20	
	On pages 4 and 5 of the booklet, draw, label, and briefly describe an aeroponics system.	20	
	On pages 6 and 7 of the booklet draw, label, and briefly describe an aggregate culture system.	20	
	Listing of advantages and disadvantages	20	
	Total Points for Content		
	Drawings are colored.	5	
	Labeling is neat and readable.	5	
	Descriptions are neat and readable.	5	
	Total for Points for Neatness and Readability		
	TOTAL POINTS OBTAINED		

This booklet should take four standard (8 ½ x 11 inches) pages, folded in half.

Name: _____

Date: _____

Period: _____

Media Experiment Data Sheet and Rubric (7.5)

Media Experiment Assignment - Worth 100 points

Instructions: There will be three to four replications per media treatments. Plants will be labeled according to media treatment and rep. Quantitative data to be collected prior to experiment will be plant height; qualitative data will be plant vigor (1=poor, 5=best). After 1 month, rating will be repeated. Note: media treatment can be modified to instructor preference. Same data chart should be used at the beginning and end of the experiment. Pictures should be taken.

Students Names in Group: _____

Planting Date: _____ Data Collection Date: _____

Media Treatments	Plant Height				Plant Vigor				Comments
	R1	R2	R3	R4	R1	R2	R3	R4	
Organic Soil Amendment									
Inorganic Soil Amendment									
Control (No Amendment)									

Rubric for Media Experiment (7.5)

	Possible Points	Score
Procedure: Procedures for conducting the experiment should be written in detail, including the all materials used, treatment materials used, and procedures for tending to the plants. A hypothesis should be stated.	25	
Data Collection: Data should be collected accurately following a standard procedure.	25	
Results: Results should be summarized and reported in graphic and narrative form and should include a conclusion and recommendation.	50	

Name: _____

Date: _____

Period: _____

Plant Maintenance Log Rubric (7.6)

	Exemplary	Accomplished	Developing	Beginning	Score
Content	Content is accurate and detailed and applies to agricultural production practices. (60 points)	Content is accurate but general in nature with some application to agricultural practices. (45 points)	Content is accurate but general in nature with limited application to agricultural practices. (30 points)	Content does not focus on assigned topic, is inaccurate, or is totally unrelated to agricultural practices. (10 points)	
Grammar	Correct and effective use of grammar and mechanics (20 points)	Occasional minor errors in use of grammar and mechanics (15 points)	Problems in use of grammar and mechanics (10 points)	Repeated errors in use of grammar and mechanics (5 points)	
Organization	Ideas flow smoothly and logically with clarity and coherence. (20 points)	Logical order and appropriate sequencing of ideas with adequate transition (15 points)	Some evidence of an organizational plan or strategy (10 points)	Lacks organization (5 points)	
TOTAL					

Comments

Name: _____

Date: _____

Period: _____

Paragraph Construction Rubric (7.7)

CONTENTS of PARAGRAPH	PTS Worth	PTS Received
Paragraph Construction		
Used an introductory sentence that was interesting and appropriate	15	
Used at least five sentences to summarize major observations	50	
Used the list of terms as assigned	25	
Saved paragraph in assigned location using proper file name	10	
SUBTOTAL		
SENTENCE STRUCTURE – (-2 for each error listed below)		
• Redundant use of pronouns (ex. I, my)		
• Sentences too long (>21 words or 3 typed lines)		
• Capitalization, punctuation, grammar, spelling, etc.		
GRAND TOTAL		

Name: _____

Date: _____

Period: _____

Guest Speaker Evaluation Form (7.8)

1. List five main ideas expressed in the presentation.

1. _____
2. _____
3. _____
4. _____
5. _____

2. Write a brief summary relating the topics of the presentation to your life.

Name: _____

Date: _____

Period: _____

Dirty Jobs Presentation Rubric (7.9)

Presentation Content		
• Introduction slide with description and picture of crop	5	
• Products harvested	10	
• Timing of harvest (includes comments on maturity/perishability, nutrition, and marketing)	10	
• Harvesting equipment and procedures	10	
• Storage procedures	10	
• Discussion of preharvest loss and harvest loss	10	
• Summary (no new information presented)	10	
• Reference page	5	
SUBTOTAL FOR CONTENT (70 POINTS)		
Slide Format		
• Bulleted list, NOT PARAGRAPHS	5	
• Text format/capitalization consistency (i.e., titles, bullets)	5	
• Transition and effect	5	
SUBTOTAL FOR SLIDES (15 points total)		
Presentation of Information		
• Voice projection	3	
• Eye contact with audience	3	
• Familiar with content	3	
• Individual role-play of character in dirty job activity	3	
• Group participation	3	
SUBTOTAL FOR PRESENTATION (15 points total)		
TOTAL POINTS		

Name: _____

Date: _____

Period: _____

Soil and Water Conservation Graphic Rubric (7.10)

	Possible Points	Score
• Conservation message completeness and accuracy	50	
• Visual effectiveness	30	
• Originality	10	
• Universal Appeal	10	
TOTAL (100 POINTS)		

Name: _____

Date: _____

Period: _____

Pest Identification Chart (8.1)

PEST IDENTIFICATION CHART - 100 points Collect 10 samples, and fill in the chart. (2 pts each)				
Student Name:			Date:	
Pest Name	Type of Pest (i.e., weed, insect, disease)	Location Collected	Type of Damage	Biological Control Recommendation

Name: _____

Date: _____

Period: _____

Beneficial Insects Ag News Report Rubric (8.2)

Your instructor will assign you one of the beneficial insects listed below. Prepare a 1–2-min Ag News Report that includes the following information: (1) picture of the insect, (2) plants that are associated with the insect, and (3) pests that they aid in controlling.

Ladybugs
Praying mantis
Bees
Parasitic wasps

Name	Topic Presented	Introduction (name and source)	Relevant to Subject	Posture	Voice Projection	Eye Contact with Audience	Familiarity with Content	Visual Aid	Answers Questions	Total

Grading Instructions

Each News Report should be no less than 1 min and no more than 2. Teacher will hold up a sign at ½ min, 1 min, and 2 min. There will be a 5 point deduction for less than 1 and more than 2, unless permission and/or different instruction are given from teacher.

REMEMBER THERE WILL BE 10 POINTS DEDUCTED FOR EACH DAY LATE.

Name: _____

Date: _____

Period: _____

Pesticide Label Interpretation Assignment (8.3)

Your teacher will assign you a specific chemical pesticide. You are to search the Internet, locate a label for this chemical, and answer the following questions:

1. What is the active ingredient in this product and its percentage?
2. What personal protective equipment should be used when working with this pesticide?
3. What pests does this pesticide control?
4. How is this pesticide applied, and what plants are approved for its use?
5. What type(s) of formulation(s) are manufactured for this chemical?
6. If someone accidentally swallowed this material, what should you do?

Name: _____

Date: _____

Period: _____

Integrated Pest Management Plan Rubric (8.4)

Component:	Possible Points	Score
Background: The plan clearly identified the plants to be protected under the plan and the most commonly associated pests including weeds, diseases, and insects. Life cycle and damage caused by each pest was described.	25	
Cultural and Mechanical Controls: The plan identified and described how cultural and mechanical pest control methods would be implemented and maintained during the growing season.	25	
Biological Controls: The plan identified any biological controls that would be implemented and maintained during the growing season.	25	
Chemical Controls: The plan identified chemical controls that would be used including the economic threshold that would cause chemicals to be applied and specific chemicals and formulations that would be used.	25	
		Total

Appendix B: 21st Century Skills Standards

CSS1-21st Century Themes

CS1 Global Awareness

1. Using 21st century skills to understand and address global issues
2. Learning from and working collaboratively with individuals representing diverse cultures, religions, and lifestyles in a spirit of mutual respect and open dialogue in personal, work, and community contexts
3. Understanding other nations and cultures, including the use of non-English languages

CS2 Financial, Economic, Business and Entrepreneurial Literacy

1. Knowing how to make appropriate personal economic choices
2. Understanding the role of the economy in society
3. Using entrepreneurial skills to enhance workplace productivity and career options

CS3 Civic Literacy

1. Participating effectively in civic life through knowing how to stay informed and understanding governmental processes
2. Exercising the rights and obligations of citizenship at local, state, national, and global levels
3. Understanding the local and global implications of civic decisions

CS4 Health Literacy

1. Obtaining, interpreting and understanding basic health information and services and using such information and services in ways that enhance health
2. Understanding preventive physical and mental health measures, including proper diet, nutrition, exercise, risk avoidance, and stress reduction
3. Using available information to make appropriate health-related decisions
4. Establishing and monitoring personal and family health goals
5. Understanding national and international public health and safety issues

CS5 Environmental Literacy

1. Demonstrate knowledge and understanding of the environment and the circumstances and conditions affecting it, particularly as relates to air, climate, land, food, energy, water, and ecosystems
2. Demonstrate knowledge and understanding of society's impact on the natural world (e.g., population growth, population development, resource consumption rate, etc.)
3. Investigate and analyze environmental issues, and make accurate conclusions about effective solutions
4. Take individual and collective action towards addressing environmental challenges (e.g., participating in global actions, designing solutions that inspire action on environmental issues)

CSS2-Learning and Innovation Skills

CS6 Creativity and Innovation

1. Think Creatively
2. Work Creatively with Others
3. Implement Innovations

CS7 Critical Thinking and Problem Solving

1. Reason Effectively
2. Use Systems Thinking
3. Make Judgments and Decisions
4. Solve Problems

CS8 Communication and Collaboration

1. Communicate Clearly

2. Collaborate with Others

CSS3-Information, Media and Technology Skills

- CS9 Information Literacy**
 1. Access and Evaluate Information
 2. Use and Manage Information
- CS10 Media Literacy**
 1. Analyze Media
 2. Create Media Products
- CS11 ICT Literacy**
 1. Apply Technology Effectively

CSS4-Life and Career Skills

- CS12 Flexibility and Adaptability**
 1. Adapt to change
 2. Be Flexible
- CS13 Initiative and Self-Direction**
 1. Manage Goals and Time
 2. Work Independently
 3. Be Self-directed Learners
- CS14 Social and Cross-Cultural Skills**
 1. Interact Effectively with others
 2. Work Effectively in Diverse Teams
- CS15 Productivity and Accountability**
 1. Manage Projects
 2. Produce Results
- CS16 Leadership and Responsibility**
 1. Guide and Lead Others
 2. Be Responsible to Others

Appendix C: MS Academic Standards

MISSISSIPPI SCIENCE FRAMEWORK COMPETENCIES

Marine and Aquatic Science

- AQ 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- AQ 2 Develop an understanding of physical and chemical properties of water and aquatic environments.
- AQ 3 Apply an understanding of the diverse organisms found in aquatic environments.
- AQ 4 Draw conclusions about the relationships between human activity and aquatic organisms.

1. **Apply inquiry-based and problem-solving processes and skills to scientific investigations.**
 - a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
 - b. Formulate questions that can be answered through research and experimental design. (DOK 3)
 - c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
 - e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
2. **Develop an understanding of physical and chemical properties of water and aquatic environments.**
 - a. Analyze the physical and chemical properties of water, and justify why it is essential to living organisms. (DOK 1)
 - b. Explain the causes and characteristics of tides. (DOK 1)
 - c. Research, create diagrams, and summarize principles related to waves and current characteristics and formation. (DOK 2)
 - d. Compare and contrast the physical and chemical parameters of dissolved O₂, pH, temperature, salinity, and results obtained through analysis of different water column depths/zones. (DOK 2)
 - e. Investigate the causes and effects of erosion and discuss conclusions. (DOK 2)
 - f. Describe and differentiate among the major geologic features of specific aquatic environments. (DOK 1)
 - Plate tectonics
 - Rise, slope, elevation, and depth
 - Formation of dunes, reefs, barrier/volcanic islands, and coastal/flood plains
 - Watershed formation as it relates to bodies of freshwater
 - g. Compare and contrast the unique abiotic and biotic characteristics of selected aquatic ecosystems. (DOK 2)
 - Barrier island, coral reef, tidal pool, and ocean
 - River, stream, lake, pond, and swamp
 - Bay, sound, estuary, and marsh
3. **Apply an understanding of the diverse organisms found in aquatic environments.**
 - a. Analyze and explain the diversity and interactions among aquatic life. (DOK 3)

- Adaptations of representative organisms for their aquatic environments
 - Relationship of organisms in food chains/webs within aquatic environments
- b. Research, calculate, and interpret population data. (DOK 2)
 - c. Research and compare reproductive processes in aquatic organisms. (DOK 2)
 - d. Differentiate among characteristics of planktonic, nektonic, and benthic organisms. (DOK 1)
 - e. Explore the taxonomy of aquatic organisms, and use dichotomous keys to differentiate among the organisms. (DOK 2)
 - f. Research and explain the symbiotic relationships in aquatic ecosystems. (DOK 3)
- 4. Draw conclusions about the relationships between human activity and aquatic organisms.**
- a. Describe the impact of natural and human activity on aquatic ecosystems, and evaluate the effectiveness of various solutions to environmental problems. (DOK 3)
 - Sources of pollution in aquatic environments and methods to reduce the effects of the pollution
 - Effectiveness of a variety of methods of environmental management and stewardship
 - Effects of urbanization on aquatic ecosystems and the effects of continued expansion
 - b. Research and cite evidence of the effects of natural phenomena such as hurricanes, floods, or drought on aquatic habitats and organisms. (DOK 3)
 - c. Discuss the advantages and disadvantages involved in applications of modern technology in aquatic science. (DOK 2)
 - Careers related to aquatic science
 - Modern technology within aquatic science (e.g., mariculture and aquaculture)
 - Contributions of aquatic technology to industry and government

Biology I

BIOI 1	Apply inquiry-based and problem-solving processes and skills to scientific investigations.
BIOI 2	Describe the biochemical basis of life, and explain how energy flows within and between the living systems.
BIOI 3	Investigate and evaluate the interaction between living organisms and their environment.
BIOI 4	Analyze and explain the structures and function of the levels of biological organization.
BIOI 5	Demonstrate an understanding of the molecular basis of heredity.
BIOI 6	Demonstrate an understanding of principles that explain the diversity of life and biological evolution.

- 1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.**
- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
 - d. Formulate questions that can be answered through research and experimental design. (DOK 3)
 - e. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 2)
 - f. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
 - g. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - h. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - i. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Describe the biochemical basis of life, and explain how energy flows within and between the living systems.

- a. Explain and compare with the use of examples the types of bond formation (e.g., covalent, ionic, hydrogen, etc.) between or among atoms. (DOK 2)
 - Subatomic particles and arrangement in atoms
 - Importance of ions in biological processes
- b. Develop a logical argument defending water as an essential component of living systems (e.g., unique bonding and properties including polarity, high specific heat, surface tension, hydrogen bonding, adhesion, cohesion, and expansion upon freezing). (DOK 2)
- c. Classify solutions as acidic, basic, or neutral, and relate the significance of the pH scale to an organism's survival (e.g., consequences of having different concentrations of hydrogen and hydroxide ions). (DOK 2)
- d. Compare and contrast the structure, properties, and principle functions of carbohydrates, lipids, proteins, and nucleic acids in living organisms. (DOK 2)
 - Basic chemical composition of each group
 - Building components of each group (e.g., amino acids, monosaccharides, nucleotides, etc.)
 - Basic functions (e.g., energy, storage, cellular, heredity) of each group
- e. Examine the life processes to conclude the role enzymes play in regulating biochemical reactions. (DOK 2)
 - Enzyme structure
 - Enzyme function, including enzyme-substrate specificity and factors that affect enzyme function (pH and temperature)
- f. Describe the role of adenosine triphosphate (ATP) in making energy available to cells. (DOK 1)
 - ATP structure
 - ATP function
- g. Analyze and explain the biochemical process of photosynthesis and cellular respiration, and draw conclusions about the roles of the reactant and products in each. (DOK 3)
 - Photosynthesis and respiration (reactants and products)
 - Light-dependent reactions and light independent reactions in photosynthesis, including requirements and products of each
 - Aerobic and anaerobic processes in cellular respiration, including products each and energy differences

3. Investigate and evaluate the interaction between living organisms and their environment.

- a. Compare and contrast the characteristics of the world's major biomes (e.g., deserts, tundra, taiga, grassland, temperate forest, tropical rainforest). (DOK 2)
 - Plant and animal species
 - Climate (temperature and rainfall)
 - Adaptations of organisms
- b. Provide examples to justify the interdependence among environmental elements. (DOK 2)
 - Biotic and abiotic factors in an ecosystem (e.g., water, carbon, oxygen, mold, leaves)
 - Energy flow in ecosystems (e.g., energy pyramids and photosynthetic organisms to herbivores, carnivores, and decomposers)
 - Roles of beneficial bacteria
 - Interrelationships of organisms (e.g., cooperation, predation, parasitism, commensalism, symbiosis, and mutualism)
- c. Examine and evaluate the significance of natural events and human activities on major ecosystems (e.g., succession, population growth, technology, loss of genetic diversity, consumption of resources). (DOK 2)

4. Analyze and explain the structures and function of the levels of biological organization.

- a. Differentiate among plant and animal cells and eukaryotic and prokaryotic cells. (DOK 2)
 - Functions of all major cell organelles and structures (e.g., nucleus, mitochondrion, rough ER, smooth ER, ribosomes, Golgi bodies, vesicles, lysosomes, vacuoles, microtubules,

- microfilaments, chloroplast, cytoskeleton, centrioles, nucleolus, chromosomes, nuclear membrane, cell wall, cell membrane [active and passive transport], cytosol)
 - Components of mobility (e.g., cilia, flagella, pseudopodia)
- b. Differentiate between types of cellular reproduction. (DOK 1)
 - Main events in the cell cycle and cell mitosis (including differences in plant and animal cell divisions)
 - Binary fission (e.g., budding, vegetative propagation, etc.)
 - Significance of meiosis in sexual reproduction
 - Significance of crossing over
- c. Describe and differentiate among the organizational levels of organisms (e.g., cells, tissues, organs, systems, types of tissues). (DOK 1)
- d. Explain and describe how plant structures (vascular and nonvascular) and cellular functions are related to the survival of plants (e.g., movement of materials, plant reproduction). (DOK 1)
- 5. **Demonstrate an understanding of the molecular basis of heredity.**
 - a. Analyze and explain the molecular basis of heredity and the inheritance of traits to successive generations by using the Central Dogma of Molecular Biology. (DOK 3)
 - Structures of DNA and RNA
 - Processes of replication, transcription, and translation
 - Messenger RNA codon charts
 - b. Utilize Mendel's laws to evaluate the results of monohybrid Punnett squares involving complete dominance, incomplete dominance, codominance, sex linked, and multiple alleles (including outcome percentage of both genotypes and phenotypes.) (DOK 2)
 - c. Examine inheritance patterns using current technology (e.g., pedigrees, karyotypes, gel electrophoresis). (DOK 2)
 - d. Discuss the characteristics and implications of both chromosomal and gene mutations. (DOK 2)
 - Significance of nondisjunction, deletion, substitutions, translocation, frame shift mutation in animals
 - Occurrence and significance of genetic disorders such as sickle cell anemia, Tay-Sachs disorder, cystic fibrosis, hemophilia, Down syndrome, color blindness
- 6. **Demonstrate an understanding of principles that explain the diversity of life and biological evolution.**
 - a. Draw conclusions about how organisms are classified into a hierarchy of groups and subgroups based on similarities that reflect their evolutionary relationships. (DOK 2)
 - Characteristics of the six kingdoms
 - Major levels in the hierarchy of taxa (e.g., kingdom, phylum/division, class, order, family, genus, and species)
 - Body plans (symmetry)
 - Methods of sexual reproduction (e.g., conjugation, fertilization, pollination)
 - Methods of asexual reproduction (e.g., budding, binary fission, regeneration, spore formation)
 - b. Critique data (e.g., comparative anatomy, Biogeography, molecular biology, fossil record, etc.) used by scientists (e.g., Redi, Needham, Spallanzani, Pasteur) to develop an understanding of evolutionary processes and patterns. (DOK 3)
 - c. Research and summarize the contributions of scientists (including Darwin, Malthus, Wallace, Lamarck, and Lyell) whose work led to the development of the theory of evolution. (DOK 2)
 - d. Analyze and explain the roles of natural selection, including the mechanisms of speciation (e.g., mutations, adaptations, geographic isolation) and applications of speciation (e.g., pesticide and antibiotic resistance). (DOK 3)
 - e. Differentiate among chemical evolution, organic evolution, and the evolutionary steps along the way to aerobic heterotrophs and photosynthetic autotrophs. (DOK 2)

Biology II

BIOII 1	Apply inquiry-based and problem-solving processes and skills to scientific investigations.
BIOII 2	Describe and contrast the structures, functions, and chemical processes of the cell.
BIOII 3	Investigate and discuss the molecular basis of heredity.
BIOII 4	Demonstrate an understanding of the factors that contribute to evolutionary theory and natural selection.
BIOII 5	Develop an understanding of organism classification.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- Use current technologies such as CD-ROM, DVD, Internet, and on-line data search to explore current research related to a specific topic. (DOK 3)
- Clarify research questions and design laboratory investigations. (DOK 3)
- Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
- Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
- Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)

2. Describe and contrast the structures, functions, and chemical processes of the cell.

- Relate the structure and function of a selectively permeable membrane to its role in diffusion and osmosis. (DOK 2)
- Summarize how cell regulation controls and coordinates cell growth and division. (DOK 2)
- Analyze and describe the function of enzymes in biochemical reactions. (DOK 2)
 - The impact of enzymatic reactions on biochemical processes
 - Factors that affect enzyme function (e.g., pH, concentration, temperature, etc.)
- Differentiate between photosynthesis and cellular respiration. (DOK 2)
 - Cellular sites and major pathways of anaerobic and aerobic respiration (with reactants, products, and ATP per monosaccharide)
 - Cellular respiration with respect to the sites at which they take place, the reactions involved, and the energy input and output in each stage (e.g., glycolysis, Krebs cycle, electron transport chain)
 - Pigments, absorption, reflection of light, and light-dependent and light-independent reactions of photosynthesis
 - Oxidation and reduction reactions

3. Investigate and discuss the molecular basis of heredity.

- Explain how the process of meiosis clarifies the mechanism underlying Mendel's conclusions about segregation and independent assortment on a molecular level. (DOK 1)
- Research and explain how major discoveries led to the determination of DNA structure. (DOK 2)
- Relate gene expression (e.g., replication, transcription, translation) to protein structure and function. (DOK 2)
 - Translation of a messenger RNA strand into a protein
 - Processing by organelles so that the protein is appropriately packaged, labeled, and eventually exported by the cell
 - Messenger RNA codon charts to determine the effects of different types of mutations on amino acid sequence and protein structure (e.g., sickle cell anemia resulting from base substitution mutation)
 - Gene expression regulated in organisms so that specific proteins are synthesized only when they are needed by the cell (e.g., allowing cell specialization)
- Assess the potential implications of DNA technology with respect to its impact on society. (DOK 3)

- Modern DNA technologies (e.g., polymerase chain reaction (PCR), gene splicing, gel electrophoresis, transformation, recombinant DNA) in agriculture, medicine, and forensics
 - e. Develop a logical argument defending or refuting bioethical issues arising from applications of genetic technology (e.g., the human genome project, cloning, gene therapy, stem cell research). (DOK 3)
- 4. Demonstrate an understanding of the factors that contribute to evolutionary theory and natural selection.**
- a. Explain the history of life on earth, and infer how geological changes provide opportunities and constraints for biological evolution. (DOK 2)
 - Main periods of the geologic timetable of earth's history
 - Roles of catastrophic and gradualistic processes in shaping planet Earth
 - b. Provide support for the argument based upon evidence from anatomy, embryology, biochemistry, and paleontology that organisms descended with modification from common ancestry. (DOK 2)
 - c. Identify and provide supporting evidence for the evolutionary relationships among various organisms using phylogenetic trees and cladograms. (DOK 2)
 - d. Formulate a scientific explanation based on fossil records of ancient life-forms, and describe how new species could originate as a result of geological isolation and reproductive isolation. (DOK 2)
 - e. Compare and contrast the basic types of selection (e.g., disruptive, stabilizing, directional, etc.). (DOK 2)
 - f. Cite examples to justify behaviors that have evolved through natural selection (e.g., migration, parental care, use of tools, etc.). (DOK 1)
 - g. Research and explain the contributions of 19th century scientists (e.g., Malthus, Wallace, Lyell, and Darwin) on the formulation of ideas about evolution. (DOK 2)
 - h. Develop a logical argument describing ways in which the influences of 20th century science have impacted the development of ideas about evolution (e.g., synthetic theory of evolution, molecular biology). (DOK 3)
 - i. Analyze changes in an ecosystem resulting from natural causes (succession), changes in climate, human activity (pollution and recycling), or introduction of nonnative species. (DOK 2)
- 5. Develop an understanding of organism classification.**
- a. Classify organisms according to traditional Linnaean classification characteristics (e.g., cell structure, biochemistry, anatomy, fossil record, methods of reproduction) and the cladistic approach. (DOK 2)
 - b. Categorize organisms according to the characteristics that distinguish them as Bacteria, Archaea, or Eucarya. (DOK 1)
 - Bacteria, fungi, and protists
 - Characteristics of invertebrates (e.g., habitat, reproduction, body plan, locomotion) as related to phyla (e.g., Porifera, Cnidarians, Nematoda, Annelida, Platyhelminthes, and Arthropoda) and classes (e.g., Insecta, Crustacea, Arachnida, Mollusca, Echinodermata)
 - Characteristics of vertebrates (e.g., habitat, reproduction, body plan, locomotion) as related to classes (e.g., Agnatha, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, Mammalia)
 - Nomenclature of various types of plants (e.g., Bryophyta, Tracheophyta, Gymnospermae, Angiospermae, Monocotyledonae, Dicotyledonae, vascular plants, nonvascular plants)

Botany

- BO 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- BO 2 Distinguish among the characteristics of botanical organization, structure, and function.
- BO 3 Demonstrate an understanding of plant reproduction.
- BO 4 Draw conclusions about the factors that affect the adaptation and survival of plants.
- BO 5 Relate an understanding of plant genetics to its uses in modern living.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols

- Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
 - c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
 - e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
- 2. Distinguish among the characteristics of botanical organization, structure, and function.**
- a. Relate plant cell structures to their functions (e.g., major organelles, cell wall components, photosynthetic chemical reactions, plant pigments, plant tissues, roots, stems, leaves, flowers). (DOK 1)
 - b. Differentiate the characteristics found in various plant divisions. (DOK 2)
 - Differences and similarities of nonvascular plants
 - Characteristics of seed-bearing and non-seed bearing vascular plants relative to taxonomy
 - Major vegetative structures and their modifications in angiosperms and gymnosperms
 - c. Compare and contrast leaf modifications of gymnosperms and angiosperms (e.g., needles, overlapping scales, simple leaves, compound leaves, evergreen trees, and deciduous trees). (DOK 2)
 - d. Apply the modern classification scheme utilized in naming plants to identify plant specimens. (DOK 2)
 - Classification scheme used in botany
 - Classification of native Mississippi plants
 - e. Use inquiry to investigate and discuss the physical and chemical processes of plants. (DOK 3)
 - Relationships among photosynthesis, cellular respiration, and translocation
 - Importance of soil type and soil profiles to plant survival
 - Mechanism of water movement in plants
 - Effects of environmental conditions for plant survival
 - Tropic responses of a plant organ to a given stimulus
- 3. Demonstrate an understanding of plant reproduction.**
- a. Compare and contrast reproductive structures (e.g., cones, flowers). (DOK 2)
 - b. Differentiate among the vegetative organs of monocots, herbaceous dicots, and woody dicots. (DOK 1)
 - c. Differentiate between the structures and processes of sexual and asexual reproduction in plants. (DOK 1)
 - Reproductive structures, their modifications, and the mechanisms involved in plant reproduction
 - Functions of flower parts, seeds, cones
 - Spore production in bryophytes and ferns
 - d. Explain and provide examples of the concept of alternation of generations and its examples. (DOK 2)
 - e. Categorize types of fruits and methods of seed distribution in plants. (DOK 1)
 - f. Research and compare various methods of plant propagation. (DOK 2)
- 4. Draw conclusions about the factors that affect the adaptation and survival of plants.**
- a. List and assess several adaptations of plants to survive in a given biome. (DOK 2)
 - b. Design and conduct an experiment to determine the effects of environmental factors on photosynthesis. (DOK 3)
 - c. Explain how natural selection and the evolutionary consequences (e.g., adaptation or extinction) support scientific explanations for similarities of ancient life-forms in the fossil record and molecular similarities present in living organisms. (DOK 2)
 - d. Research factors that might influence or alter plant stability, and propose actions that may reduce the negative impacts of human activity. (DOK 2)
- 5. Relate an understanding of plant genetics to its uses in modern living.**
- a. Research, prepare, and present a position relating to issues surrounding the current botanical trends involving biotechnology. (DOK 3)

- b. Apply an understanding of the principles of plant genetics to analyze monohybrid and dihybrid crosses, and predict the potential effects the crosses might have on agronomy and agriculture. (DOK 3)
- c. Discuss the effects of genetic engineering of plants on society. (DOK 2)
- d. Describe the chemical compounds extracted from plants, their economical importance, and the impact on humans. (DOK 3)
 - Plant extracts, their function, and origin
 - Impact of the timber industry on local and national economy

Chemistry I

- CHI 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- CHI 2 Demonstrate an understanding of the atomic model of matter by explaining atomic structure and chemical bonding.
- CHI 3 Develop an understanding of the periodic table.
- CHI 4. Analyze the relationship between microscopic and macroscopic models of matter.
- CHI 5 Compare factors associated with acid/base and oxidation/reduction reactions.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
- b. Clarify research questions and design laboratory investigations. (DOK 3)
- c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
- e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
- f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBLs, etc.). (DOK 3)

2. Demonstrate an understanding of the atomic model of matter by explaining atomic structure and chemical bonding.

- a. Describe and classify matter based on physical and chemical properties and interactions between molecules or atoms. (DOK 1)
 - Physical properties (e.g., melting points, densities, boiling points) of a variety of substances
 - Substances and mixtures
 - Three states of matter in terms of internal energy, molecular motion, and the phase transitions between them
- b. Research and explain crucial contributions and critical experiments of Dalton, Thomson, Rutherford, Bohr, de Broglie, and Schrödinger, and describe how each discovery contributed to the current model of atomic and nuclear structure. (DOK 2)
- c. Develop a model of atomic and nuclear structure based on theory and knowledge of fundamental particles. (DOK 2)
 - Properties and interactions of the three fundamental particles of the atom
 - Laws of conservation of mass, constant composition, definite proportions, and multiple proportions
- d. Write appropriate equations for nuclear decay reactions, describe how the nucleus changes during these reactions, and compare the resulting radiation with regard to penetrating ability. (DOK 1)
 - Three major types of radioactive decay (e.g., alpha, beta, gamma) and the properties of the emissions (e.g., composition, mass, charge, penetrating power)
 - The concept of half-life for a radioactive isotope (e.g., carbon-14 dating) based on the principle that the decay of any individual atom is a random process

- e. Compare the properties of compounds according to their type of bonding. (DOK 1)
 - Covalent, ionic, and metallic bonding
 - Polar and nonpolar covalent bonding
 - Valence electrons and bonding atoms
 - f. Compare different types of intermolecular forces, and explain the relationship between intermolecular forces, boiling points, and vapor pressure when comparing differences in properties of pure substances. (DOK 1)
 - g. Develop a three-dimensional model of molecular structure. (DOK 2)
 - Lewis dot structures for simple molecules and ionic compounds
 - Valence shell electron pair repulsion theory (VSEPR)
- 3. Develop an understanding of the periodic table.**
- a. Calculate the number of protons, neutrons, and electrons in individual isotopes using atomic numbers and mass numbers, write electron configurations of elements and ions following the Aufbau principle, and balance equations representing nuclear reactions. (DOK 1)
 - b. Analyze patterns and trends in the organization of elements in the periodic table, and compare their relationship to position in the periodic table. (DOK 2)
 - Atomic number, atomic mass, mass number, and number of protons, electrons, and neutrons in isotopes of elements
 - Average atomic mass calculations
 - Chemical characteristics of each region
 - Periodic properties (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity, electron affinity, ionization energy, atomic/covalent/ionic radius)
 - c. Classify chemical reactions by type. (DOK 2)
 - Single displacement, double displacement, synthesis (combination), decomposition, disproportionation, combustion, or precipitation
 - Products (given reactants) or reactants (given products) for each reaction type
 - Solubility rules for precipitation reactions and the activity series for single and double displacement reactions
 - d. Use stoichiometry to calculate the amount of reactants consumed and products formed. (DOK 3)
 - Difference between chemical reactions and chemical equations
 - Formulas and calculations of the molecular (molar) masses
 - Empirical formula given the percent composition of elements
 - Molecular formula given the empirical formula and molar mass
- 4. Analyze the relationship between microscopic and macroscopic models of matter.**
- a. Calculate the number of protons, neutrons, and electrons in individual isotopes using atomic numbers and mass numbers, write electron configurations of elements and ions following the Aufbau principle, and balance equations representing nuclear reactions. (DOK 1)
 - b. Analyze patterns and trends in the organization of elements in the periodic table, and compare their relationship to position in the periodic table. (DOK 2)
 - Atomic number, atomic mass, mass number, and number of protons, electrons, and neutrons in isotopes of elements
 - Average atomic mass calculations
 - Chemical characteristics of each region
 - Periodic properties (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity, electron affinity, ionization energy, atomic/covalent/ionic radius)
 - c. Classify chemical reactions by type. (DOK 2)
 - Single displacement, double displacement, synthesis (combination), decomposition, disproportionation, combustion, or precipitation
 - Products (given reactants) or reactants (given products) for each reaction type
 - Solubility rules for precipitation reactions and the activity series for single and double displacement reactions
 - d. Use stoichiometry to calculate the amount of reactants consumed and products formed. (DOK 3)

- Difference between chemical reactions and chemical equations
 - Formulas and calculations of the molecular (molar) masses
 - Empirical formula given the percent composition of elements
 - Molecular formula given the empirical formula and molar mass
5. **Compare factors associated with acid/base and oxidation/reduction reactions.**
- a. Analyze and explain acid/base reactions. (DOK 2)
 - Properties of acids and bases, including how they affect indicators and the relative pH of the solution
 - Formation of acidic and basic solutions
 - Definition of pH in terms of the hydronium ion concentration and the hydroxide ion concentration
 - The pH or pOH from the hydrogen ion or hydroxide ion concentrations of solution
 - How a buffer works and examples of buffer solutions
 - b. Classify species in aqueous solutions according to the Arrhenius and Bronsted-Lowry definitions respectively, and predict products for aqueous neutralization reactions. (DOK 2)
 - c. Analyze a reduction/oxidation reaction (REDOX) to assign oxidation numbers (states) to reaction species, and identify the species oxidized and reduced, the oxidizing agent, and reducing agent. (DOK 2)

Organic Chemistry

- ORGC 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- ORGC 2 Demonstrate an understanding of the properties, structure, and function of organic compounds.
- ORGC 3 Discuss the versatility of polymers and the diverse application of organic chemicals.

1. **Apply inquiry-based and problem-solving processes and skills to scientific investigations.**
- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
 - b. Formulate questions that can be answered through research and experimental design. (DOK 3)
 - c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
 - e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - f. Recognize and analyze alternative explanations for experimental results, and make predictions based on observations and prior knowledge. (DOK 3)
 - g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
2. **Demonstrate an understanding of the properties, structure, and function of organic compounds.**
- a. Apply International Union of Pure and Applied Chemistry (IUPAC) nomenclature, and differentiate the structure of aliphatic, aromatic, and cyclic hydrocarbon compounds. (DOK 1)
 - Structures of hydrocarbon compounds
 - Isomerism in hydrocarbon compounds
 - b. Relate structure to physical and chemical properties of hydrocarbon. (DOK 1)
 - c. Apply principles of geometry and hybridization to organic molecules. (DOK 2)
 - Lewis structures for organic molecules
 - Bond angles
 - Hybridization (as it applies to organic molecules)
 - d. Write, complete, and classify common reactions for aliphatic, aromatic, and cyclic hydrocarbons. (DOK 1)
 - e. Construct, solve, and explain equations representing combustion reactions, substitution reactions, dehydrogenation reactions, and addition reactions. (DOK 2)

- f. Classify functional groups (e.g., alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides, and nitriles) by their structure and properties. (DOK 2)
- Structural formulas from functional group names and vice versa
 - Chemical and physical properties of compounds containing functional groups
 - Equations representing the transformation of one functional group into another
3. **Discuss the versatility of polymers and the diverse application of organic chemicals.**
- a. Describe and classify the synthesis, properties, and uses of polymers. (DOK 2)
- Common polymers
 - Synthesis of polymers from monomers by addition or condensation
 - Condensations of plastics according to their commercial types
 - Elasticity and other polymer properties
- b. Develop a logical argument supporting the use of organic chemicals and their application in industry, drug manufacture, and biological chemistry. (DOK 1)
- Common uses of polymers and organic compounds in medicine, drugs, and personal care products
 - Compounds that have the property to dye materials
 - Petrochemical production
 - Biologically active compounds in terms of functional group substrate interaction
- c. Research and summarize the diversity, applications, and economics of industrial chemicals (solvents, coatings, surfactants, etc.). (DOK 3)

Earth and Space Science

- E1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- E2 Develop an understanding of the history and evolution of the universe and earth.
- E3 Discuss factors that are used to explain the geological history of earth.
- E4 Demonstrate an understanding of earth systems relating to weather and climate.
- E5 Apply an understanding of ecological factors to explain relationships between earth systems.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
- Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers.
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Develop an understanding of the history and evolution of the universe and earth.

- a. Summarize the origin and evolution of the universe. (DOK 2)
- Big bang theory
 - Microwave background radiation
 - The Hubble constant
 - Evidence of the existence of dark matter and dark energy in the universe and the history of the universe

- b. Differentiate methods used to measure space distances, including astronomical unit, light-year, stellar parallax, Cepheid variables, and the red shift. (DOK 1)
 - c. Interpret how gravitational attraction played a role in the formation of the planetary bodies and how the fusion of hydrogen and other processes in “ordinary” stars and supernovae lead to the formation of all other elements. (DOK 2)
 - d. Summarize the early evolution of the earth, including the formation of Earth’s solid layers (e.g., core, mantle, and crust), the distribution of major elements, the origin of internal heat sources, and the initiation of plate tectonics. (DOK 2)
 - How the decay of radioactive isotopes is used to determine the age of rocks, earth, and the solar system
 - How Earth acquired its initial oceans and atmosphere
- 3. Discuss factors which are used to explain the geological history of earth.**
- a. Develop an understanding of how plate tectonics create certain geological features, materials, and hazards. (DOK 1)
 - Plate tectonic boundaries (e.g., divergent, convergent, and transform)
 - Modern and ancient geological features to each kind of plate tectonic boundary
 - Production of particular groups of igneous and metamorphic rocks and mineral resources
 - Sedimentary basins created and destroyed through time
 - b. Compare and contrast types of mineral deposits/groups (e.g., oxides, carbonates, halides, sulfides, sulfates, silicates, phosphates). (DOK 2)
 - c. Categorize minerals and rocks by determining their physical and/or chemical characteristics. (DOK 2)
 - d. Justify the causes of certain geological hazards (e.g., earthquakes, volcanoes, tsunamis) to their effects on specific plate tectonic locations. (DOK 2)
 - e. Interpret and explain how rock relationships and fossils are used to reconstruct the geologic history of the earth. (DOK 2)
 - f. Apply principles of relative age (e.g., superposition, original horizontality, crosscutting relations, and original lateral continuity) to support an opinion related to earth’s geological history. (DOK 3)
 - Types of unconformity (e.g., disconformity, angular unconformity, nonconformity)
 - Geological timetable
 - g. Apply the principle of uniformitarianism to relate sedimentary rock associations and their fossils to the environments in which the rocks were deposited. (DOK 2)
 - h. Compare and contrast the relative and absolute dating methods (e.g., the principle of fossil succession, radiometric dating, and paleomagnetism) for determining the age of the earth. (DOK 1)
- 4. Demonstrate an understanding of earth systems relating to weather and climate.**
- a. Explain the interaction of earth systems that affect weather and climate. (DOK 1)
 - Latitudinal variations in solar heating
 - The effects of Coriolis forces on ocean currents, cyclones, anticyclones, ocean currents, topography, and air masses (e.g., warm fronts, cold fronts, stationary fronts, and occluded fronts).
 - b. Interpret the patterns in temperature and precipitation that produce the climate regions on earth, and relate them to the hazards associated with extreme weather events and climate change (e.g., hurricanes, tornadoes, El Niño/La Niña, global warming). (DOK 2)
 - c. Justify how changes in global climate and variation in earth/sun relationships contribute to natural and anthropogenic (human-caused) modification of atmospheric composition. (DOK 2)
 - d. Summarize how past and present actions of ice, wind, and water contributed to the types and distributions of erosional and depositional features in landscapes. (DOK 1)
 - e. Research and explain how external forces affect earth’s topography. (DOK 2)
 - How surface water and groundwater act as the major agents of physical and chemical weathering
 - How soil results from weathering and biological processes
 - Processes and hazards associated with both sudden and gradual mass wasting
- 5. Apply an understanding of ecological factors to explain relationships between earth systems.**
- a. Draw conclusions about how life on earth shapes earth systems and responds to the interaction of earth systems (lithosphere, hydrosphere, atmosphere, and biosphere). (DOK 3)

- Nature and distribution of life on earth, including humans, to the chemistry and availability of water
 - Distribution of biomes (e.g., terrestrial, freshwater, and marine) to climate regions through time
 - Geochemical and ecological processes (e.g., rock, hydrologic, carbon, nitrogen) that interact through time to cycle matter and energy and how human activity alters the rates of these processes (e.g., fossil fuel formation and combustion, damming and channeling of rivers)
- b. Interpret the record of shared ancestry (fossils), evolution, and extinction as related to natural selection. (DOK 2)
 - c. Identify the cause and effect relationships of the evolutionary innovations that most profoundly shaped earth systems. (DOK 1)
 - Photosynthesis and the atmosphere
 - Multicellular animals and marine environments
 - Land plants and terrestrial environments
 - d. Cite evidence about how dramatic changes in earth's atmosphere influenced the evolution of life. (DOK 1)

Environmental Science

- ES 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- ES 2 Develop an understanding of the relationship of ecological factors that affect an ecosystem.
- ES 3 Discuss the impact of human activities on the environment, conservation activities, and efforts to maintain and restore ecosystems.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Develop an understanding of the relationship of ecological factors that affect an ecosystem.

- a. Compare ways in which the three layers of the biosphere change over time and their influence on an ecosystem's ability to support life. (DOK 2)
- b. Explain the flow of matter and energy in ecosystems. (DOK 2)
 - Interactions between biotic and abiotic factors
 - Indigenous plants and animals and their roles in various ecosystems
 - Biogeochemical cycles within the environment
- c. Predict the impact of the introduction, removal, and reintroduction of an organism on an ecosystem. (DOK 3)
- d. Develop a logical argument explaining the relationships and changes within an ecosystem. (DOK 2)
 - How a species adapts to its niche
 - Process of primary and secondary succession and its effects on a population
 - How changes in the environment might affect organisms
- e. Explain the causes and effects of changes in population dynamics (e.g., natural selection, exponential growth, predator/prey relationships) to carrying capacity and limiting factors. (DOK 2)

- f. Research and explain how habitat destruction leads to the loss of biodiversity. (DOK 2)
 - g. Compare and contrast the major biomes of the world's ecosystems, including location, climate, adaptations and diversity. (DOK 1)
- 3. Discuss the impact of human activities on the environment, conservation activities, and efforts to maintain and restore ecosystems.**
- a. Summarize the effects of human activities on resources in the local environments. (DOK 2)
 - Sources, uses, quality, and conservation of water
 - Renewable and nonrenewable resources
 - Effects of pollution (e.g., water, noise, air, etc.) on the ecosystem
 - b. Research and evaluate the impacts of human activity and technology on the lithosphere, hydrosphere, and atmosphere, and develop a logical argument to support how communities restore ecosystems. (DOK 3)
 - c. Research and evaluate the use of renewable and nonrenewable resources, and critique efforts to conserve natural resources and reduce global warming in the United States including (but not limited) to Mississippi. (DOK 3)

Genetics

- G 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
- G 2 Analyze the structure and function of the cell and cellular organelles.
- G 3 Apply the principles of heredity to demonstrate genetic understandings.

1. Use critical thinking and scientific problem solving in designing and performing biological research and experimentation. (L, P, E)

- a. Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
- b. Clarify research questions and design laboratory investigations. (DOK 3)
- c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for pie, bar, and line graphs) to draw conclusions and make inferences. (DOK 3)
- e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
- f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBLs, etc.). (DOK 3)

2. Review the structure and function of the cell as it applies to genetics. (L)

- a. Cite evidence to illustrate how the structure and function of cells are involved in the maintenance of life. (DOK 2)
- b. Describe how organic components are integral to biochemical processes. (DOK 2)
- c. Differentiate among the processes by which plants and animals reproduce. (DOK 1)
 - Cell cycle and mitosis
 - Meiosis, spermatogenesis, and oogenesis
- d. Explain the significance of the discovery of nucleic acids. (DOK 1)
- e. Analyze and explain the structure and function of DNA and RNA in replication, transcription, translation and DNA repair. (DOK 2)
- f. Cite examples to compare the consequences of the different types of mutations. (DOK 1)
- g. Draw conclusions about the importance and potential impacts of the process of gene transfer used in biotechnology. (DOK 3)

3. Analyze the structure and function of DNA and RNA molecules. (L, P)

- a. Cite evidence that supports the significance of Mendel's concept of "particulate inheritance" to explain the understanding of heredity. (DOK 1)

- b. Apply classical genetics principles to solve basic genetic problems. (DOK 2)
 - Genes and alleles, dominance, recessiveness, the laws of segregation, and independent assortment
 - Inheritance of autosomal and sex-linked traits
 - Inheritance of traits influenced by multiple alleles and traits with polygenetic inheritance
 - Chromosomal theory of inheritance
- c. Apply population genetic concepts to summarize variability of multicellular organisms. (DOK 2)
 - Genetic variability
 - Hardy-Weinberg formula
 - Migration and genetic drift
 - Natural selection in humans
- d. Distinguish and explain the applications of various tools and techniques used in DNA manipulation. (DOK 1)
 - Steps in genetic engineering experiments
 - Use of restriction enzymes
 - Role of vectors in genetic research
 - Use of transformation techniques
- e. Research and present a justifiable explanation the practical uses of biotechnology (e.g., chromosome mapping, karyotyping, and pedigrees). (DOK 2)
- f. Develop and present a scientifically-based logical argument for or against moral and ethical issues related to genetic engineering. (DOK 3)
- g. Research genomics (human and other organisms), and predict benefits and medical advances that may result from the use of genome projects. (DOK 2)

Geology

GE1	Apply inquiry-based and problem-solving processes and skills to scientific investigations.
GE2	Develop an understanding of plate tectonics and geochemical and ecological processes that affect earth.

1. **Apply inquiry-based and problem-solving processes and skills to scientific investigations.**
 - a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
 - b. Formulate questions that can be answered through research and experimental design. (DOK 3)
 - c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
 - d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
 - e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
 - f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
 - g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)
2. **Develop an understanding of plate tectonics and geochemical and ecological processes that affect earth.**
 - a. Differentiate the components of the earth's atmosphere and lithosphere. (DOK 1)
 - b. Research and summarize explanations of how earth acquired its initial atmosphere and oceans. (DOK 2)
 - c. Compare the causes and effects of internal and external components that shape earth's topography. (DOK 2)
 - Physical weathering (e.g., atmospheric, glacial, etc.)
 - Chemical weathering agents (e.g., acid precipitation, carbon dioxide, oxygen, water, etc.)

- d. Develop an understanding of how plate tectonics create certain geologic features, materials, and hazards. (DOK 2)
 - Types of crustal movements and the resulting landforms (e.g., seafloor spreading, paleomagnetic measurements, and orogenesis)
 - Processes that create earthquakes and volcanoes
 - Asthenosphere
- e. Summarize the theories of plate development and continental drift, and describe the causes and effects involved in each. (DOK 2)
- f. Develop a logical argument to explain how geochemical and ecological processes (e.g., rock, hydrologic, carbon, nitrogen) interact through time to cycle matter and energy and how human activity alters the rates of these processes (e.g., fossil fuel formation and combustion, damming, and channeling of rivers). (DOK 2)
- g. Interpret how the earth's geological time scale relates to geological history, landforms, and life-forms. (DOK 2)
- h. Research and describe different techniques for determining relative and absolute age of the earth (e.g., index of fossil layers, superposition, radiometric dating, etc.) (DOK 1)
- i. Summarize the geological activity of the New Madrid fault line, and compare and contrast it to geological activity in other parts of the world. (DOK 2)
- j. Identify and differentiate the major geological features in Mississippi (e.g., Delta, Coastal Areas, etc.). (DOK 1)
- k. Evaluate an emergency preparedness plan for natural disasters associated with crustal movement. (DOK 3)

Physical Science

PS 1	Apply inquiry-based and problem-solving processes and skills to scientific investigations.
PS 2	Describe and explain how forces affect motion.
PS 3	Demonstrate an understanding of general properties and characteristics of waves.
PS 4	Develop an understanding of the atom.
PS 5	Investigate and apply principles of physical and chemical changes in matter.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Use appropriate laboratory safety symbols and procedures to design and conduct a scientific investigation. (DOK 2)
 - Safety symbols and safety rules in all laboratory activities
 - Proper use and care of the compound light microscope
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Identify questions that can be answered through scientific investigations. (DOK 3)
- c. Identify and apply components of scientific methods in classroom investigations. (DOK 3)
 - Predicting, gathering data, drawing conclusions
 - Recording outcomes and organizing data from a variety of sources (e.g., scientific articles, magazines, student experiments, etc.)
 - Critically analyzing current investigations/problems using periodicals and scientific scenarios
- d. Interpret and generate graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 2)
- e. Analyze procedures and data to draw conclusions about the validity of research. (DOK 3)
- f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- g. Communicate effectively to present and explain scientific results, using appropriate terminology and graphics. (DOK 3)

2. Describe and explain how forces affect motion.

- a. Demonstrate and explain the basic principles of Newton's three laws of motion including calculations of acceleration, force, and momentum. (DOK 2)

- Inertia and distance-time graphs to determine average speed
 - Net force (accounting for gravity, friction, and air resistance) and the resulting motion of objects
 - Effects of the gravitational force on objects on Earth and effects on planetary and lunar motion
 - Simple harmonic motion (oscillation)
- b. Explain the connection between force, work, and energy. (DOK 2)
 - Force exerted over a distance (results in work done)
 - Force-distance graph (to determine work)
 - Network on an object that contributes to change in kinetic energy (work-to-energy theorem)
 - c. Describe (with supporting details and diagrams) how the kinetic energy of an object can be converted into potential energy (the energy of position) and how energy is transferred or transformed (conservation of energy). (DOK 2)
 - d. Draw and assess conclusions about charges and electric current. (DOK 2)
 - Static/current electricity and direct current/alternating current
 - Elements in an electric circuit that are in series or parallel
 - Conductors and insulators
 - Relationship between current flowing through a resistor and voltage flowing across a resistor
 - e. Cite evidence and explain the application of electric currents and magnetic fields as they relate to their use in everyday living (e.g., the application of fields in motors and generators and the concept of electric current using Ohm's Law). (DOK 2)
- 3. Demonstrate an understanding of general properties and characteristics of waves.**
- a. Differentiate among transverse, longitudinal, and surface waves as they propagate through a medium (e.g., string, air, water, steel beam). (DOK 1)
 - b. Compare properties of waves (e.g., superposition, interference, refraction, reflection, diffraction, Doppler effect), and explain the connection among the quantities (e.g., wavelength, frequency, period, amplitude, and velocity). (DOK 2)
 - c. Classify the electromagnetic spectrum's regions according to frequency and/or wavelength, and draw conclusions about their impact on life. (DOK 2)
 - The emission of light by electrons when moving from higher to lower levels
 - Energy (photons as quanta of light)
 - Additive and subtractive properties of colors
 - Relationship of visible light to the color spectrum
 - d. Explain how sound intensity is measured and its relationship to the decibel scale. (DOK 1)
- 4. Develop an understanding of the atom.**
- a. Cite evidence to summarize the atomic theory. (DOK 1)
 - Models for atoms
 - Hund's rule and Aufbau process to specify the electron configuration of elements
 - Building blocks of matter (e.g., proton, neutron, and electron) and elementary particles (e.g., positron, mesons, neutrinos, etc.)
 - Atomic orbitals (s, p, d, f) and their basic shapes
 - b. Explain the difference between chemical and physical changes, and demonstrate how these changes can be used to separate mixtures and compounds into their components. (DOK 2)
 - c. Research the history of the periodic table of the elements, and summarize the contributions that led to the atomic theory. (DOK 2)
 - Contributions of scientists (e.g., John Dalton, J.J. Thomson, Ernest Rutherford, Newton, Einstein, Neils, Bohr, Louis de Broglie, Erwin Schrödinger, etc.)
 - Technology (e.g., X-rays, cathode-ray tubes, spectroscopes)
 - Experiments (e.g., gold-foil, cathode-ray, etc.)
 - d. Utilize the periodic table to predict and explain patterns and draw conclusions about the structure, properties, and organization of matter. (DOK 2)
 - Atomic composition and valence electron configuration (e.g., atomic number, mass number of protons, neutrons, electrons, isotopes, and ions)
 - Periodic trends using the periodic table (e.g., valence, reactivity, atomic radius)

- Average atomic mass from isotopic abundance
- Solids, liquids, and gases
- Periodic properties of elements (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity, electron affinity, ionization energy, atomic/covalent/ionic radius) and how they relate to position in the periodic table

5. Investigate and apply principles of physical and chemical changes in matter.

- Write chemical formulas for compounds comprising monatomic and polyatomic ions. (DOK 1)
- Balance chemical equations. (DOK 2)
- Classify types of chemical reactions (e, g., composition, decomposition, single displacement, double displacement, combustion, acid/base reactions). (DOK 2)

Physics I

PHYI 1	Apply inquiry-based and problem-solving processes and skills to scientific investigations.
PHYI 2	Develop an understanding of concepts related to forces and motion.
PHYI 3	Develop an understanding of concepts related to work and energy.
PHYI 4	Discuss the characteristics and properties of light and sound.
PHYI 5	Apply an understanding of magnetism, electric fields, and electricity.
PHYI 6	Analyze and explain concepts of nuclear physics.

1. Investigate and apply principles of physical and chemical changes in matter.

- Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
- Clarify research questions, and design laboratory investigations. (DOK 3)
- Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences. (DOK 3)
- Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
- Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)

2. Develop an understanding of concepts related to forces and motion.

- Use inquiry to investigate and develop an understanding of the kinematics and dynamics of physical bodies. (DOK 3)
 - Vector and scalar quantities
 - Vector problems (solved mathematically and graphically)
 - Vector techniques and free-body diagrams to determine the net force on a body when several forces are acting on it
 - Relations among mass, inertia, and weight
- Analyze, describe, and solve problems by creating and utilizing graphs of one-dimensional motion (e.g., position, distance, displacement, time, speed, velocity, acceleration, the special case of freefall). (DOK 2)
- Analyze real-world applications to draw conclusions about Newton's three laws of motion. (DOK 2)
- Apply the effects of the universal gravitation law to graph and interpret the force between two masses, acceleration due to gravity, and planetary motion. (DOK 2)
 - Situations where g is constant (falling bodies)
 - Concept of centripetal acceleration undergoing uniform circular motion
 - Kepler's third law
 - Oscillatory motion and the mechanics of waves

3. Develop an understanding of concepts related to work and energy.

- Explain and apply the conservation of energy and momentum. (DOK 2)

- Concept of work and applications
 - Concept of kinetic energy, using the elementary work-energy theorem
 - Concept of conservation of energy with simple examples
 - Concepts of energy, work, and power (qualitatively and quantitatively)
 - Principles of impulse in inelastic and elastic collisions
- b. Analyze real-world applications to draw conclusions about mechanical potential energy (the energy of configuration). (DOK 3)
 - c. Apply the principles of impulse, and compare conservation of momentum and conservation of kinetic energy in perfectly inelastic and elastic collisions. (DOK 1)
 - d. Investigate and summarize the principles of thermodynamics. (DOK 2)
 - How heat energy is transferred from higher temperature to lower temperature until equilibrium is reached
 - Temperature and thermal energy as related to molecular motion and states of matter
 - Problems involving specific heat and heat capacity
 - First and second laws of thermodynamics as related to heat engines, refrigerators, and thermal efficiency
 - e. Develop the kinetic theory of ideal gases and explain the concept of Carnot efficiency. (DOK 2)
- 4. Discuss the characteristics and properties of light and sound.**
- a. Describe and model the characteristics and properties of mechanical waves. (DOK 2)
 - Simple harmonic motion
 - Relationships among wave characteristics such as velocity, period, frequency, amplitude, phase, and wavelength
 - Energy of a wave in terms of amplitude and frequency.
 - Standing waves and waves in specific media (e.g., stretched string, water surface, air, etc.)
 - b. Differentiate and explain the Doppler effect as it relates to a moving source and to a moving observer. (DOK 1)
 - c. Explain the laws of reflection and refraction, and apply Snell's law to describe the relationship between the angles of incidence and refraction. (DOK 2)
 - d. Use ray tracing and the thin lens equation to solve real-world problems involving object distance from lenses. (DOK 2)
 - e. Investigate and draw conclusions about the characteristics and properties of electromagnetic waves. (DOK 2)
- 5. Apply an understanding of magnetism, electric fields, and electricity.**
- a. Analyze and explain the relationship between electricity and magnetism. (DOK 2)
 - Characteristics of static charge and how a static charge is generated
 - Electric field, electric potential, current, voltage, and resistance as related to Ohm's law
 - Magnetic poles, magnetic flux and field, Ampère's law and Faraday's law
 - Coulomb's law
 - b. Use schematic diagrams to analyze the current flow in series and parallel electric circuits, given the component resistances and the imposed electric potential. (DOK 2)
 - c. Analyze and explain the relationship between magnetic fields and electrical current by induction, generators, and electric motors. (DOK 2)
- 6. Analyze and explain concepts of nuclear physics.**
- a. Analyze and explain the principles of nuclear physics. (DOK 1)
 - The mass number and atomic number of the nucleus of an isotope of a given chemical element
 - The conservation of mass and the conservation of charge
 - Nuclear decay
 - b. Defend the wave-particle duality model of light, using observational evidence. (DOK 3)
 - Quantum energy and emission spectra
 - Photoelectric and Compton effects

Spatial Information Science

- SP 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
SP 2 Develop an understanding of geographic information systems.

1. Demonstrate the basic concepts of global positioning systems (GPS). (E)

- a. Use current technologies such as CD-ROM, DVD, Internet, and online data search to explore current research related to a specific topic. (DOK 3)
- b. Clarify research questions, and design laboratory investigations. (DOK 3)
- c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, and theory development). (DOK 3)
- d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs), draw conclusions, and make inferences). (DOK 3)
- e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)
- f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)
- g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.). (DOK 3)

2. Demonstrate the basic concepts of remote sensing. (E, P)

- a. Describe the characteristics of the electromagnetic spectrum.
- b. Using images and graphs, interpret the absorption/reflection spectrum.
- c. Distinguish between passive vs. active sensor systems.
- d. Analyze the effects of changes in spatial, temporal, and spectral resolution.
- e. Analyze the effects on images due to changes in scale.
- f. Identify the types of sensor platforms.

Zoology

- ZO 1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
ZO 2 Develop an understanding of levels of organization and animal classification.
ZO 3 Differentiate among animal life cycles, behaviors, adaptations, and relationships.
ZO 4 Demonstrate an understanding of the principles of animal genetic diversity and evolution.

1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Conduct a scientific investigation demonstrating safe procedures and proper care of laboratory equipment. (DOK 2)
 - Safety rules and symbols
 - Proper use and care of the compound light microscope, slides, chemicals, etc.
 - Accuracy and precision in using graduated cylinders, balances, beakers, thermometers, and rulers
- b. Formulate questions that can be answered through research and experimental design. (DOK 3)
- c. Apply the components of scientific processes and methods in classroom and laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)
- d. Construct and analyze graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs). (DOK 3)
- e. Analyze procedures, data, and conclusions to determine the scientific validity of research. (DOK 3)
- f. Recognize and analyze alternative explanations for experimental results and to make predictions based on observations and prior knowledge. (DOK 3)
- g. Communicate and defend a scientific argument in oral, written, and graphic form. (DOK 3)

2. Develop an understanding of levels of organization and animal classification.

- a. Explain how organisms are classified, and identify characteristics of major groups. (DOK 1)
 - Levels of organization of structures in animals (e.g., cells, tissues, organs, and systems)

- Characteristics used to classify organisms (e.g., cell structure, biochemistry, anatomy, fossil record, and methods of reproduction)
- b. Identify and describe characteristics of the major phyla. (DOK 1)
 - Symmetry and body plan
 - Germ layers and embryonic development
 - Organ systems (e.g., digestive, circulatory, excretory, and reproductive)
 - Locomotion and coordination
 - c. Distinguish viruses from bacteria and protists, and give examples. (DOK 1)
 - d. Differentiate among the characteristics of bacteria, archaea, and eucarya. (DOK 1)
 - Phylogenetic sequencing of the major phyla
 - Invertebrate characteristics (e.g., habitat, reproduction, body plan, locomotion) of the following phyla: Porifera, Cnidarians, Nematoda, Annelida, Platyhelminthes, Arthropoda, Insecta, Crustacea, Arachnida, Mollusca [Bivalvia and Gastropoda], and Echinodermata)
 - Vertebrate characteristics (e.g., habitat, reproduction, body plan, locomotion) of the following classes: Agnatha, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, and Mammalia
- 3. Differentiate among animal life cycles, behaviors, adaptations, and relationships.**
- a. Describe life cycles, alternation of generations, and metamorphosis of various animals, and evaluate the advantages and disadvantages of asexual and sexual reproduction. (DOK 1)
 - b. Describe and explain concepts of animal behavior, and differentiate between learned and innate behavior. (DOK 1)
 - Division of labor within a group of animals
 - Communication within animals groups
 - Degree of parental care given in animal groups
 - c. Evaluate the unique protective adaptations of animals as they relate to survival. (DOK 2)
 - d. Compare and contrast ecological relationships, and make predictions about the survival of populations under given circumstances. (DOK 3)
 - Terrestrial and aquatic ecosystems
 - Herbivores, carnivores, omnivores, decomposers and other feeding relationships
 - Symbiotic relationships such as mutualism, commensalisms, and parasitism
 - e. Contrast food chains and food webs. (DOK 2)
- 4. Demonstrate an understanding of the principles of animal genetic diversity and evolution.**
- a. Categorize and explain sources of genetic variation on the cellular level (e.g., mutations, crossing over, and nondisjunction) and the population level (e.g., nonrandom mating, migration, etc.). (DOK 2)
 - Relationship between natural selection and evolution
 - Mutations, crossing over, non-disjunction
 - Nonrandom mating, migration, etc.
 - Effects of genetic drift on evolution
 - b. Develop a logical argument defending or refuting issues related to genetic engineering of animals. (DOK 3)

Appendix D: ACT College Readiness Standards

English

E1 Topic Development in Terms of Purpose and Focus

- Identify the basic purpose or role of a specified phrase or sentence.
- Delete a clause or sentence because it is obviously irrelevant to the essay.
- Identify the central idea or main topic of a straightforward piece of writing.
- Determine relevancy when presented with a variety of sentence-level details.
- Identify the focus of a simple essay, applying that knowledge to add a sentence that sharpens that focus or to determine if an essay has met a specified goal.
- Delete material primarily because it disturbs the flow and development of the paragraph.
- Add a sentence to accomplish a fairly straightforward purpose such as illustrating a given statement.
- Apply an awareness of the focus and purpose of a fairly involved essay to determine the rhetorical effect and suitability of an existing phrase or sentence or to determine the need to delete plausible but irrelevant material.
- Add a sentence to accomplish a subtle rhetorical purpose such as to emphasize, to add supporting detail, or to express meaning through connotation.
- Determine whether a complex essay has accomplished a specific purpose.
- Add a phrase or sentence to accomplish a complex purpose, often expressed in terms of the main focus of the essay.

E2 Organization, Unity, and Coherence

- Use conjunctive adverbs or phrases to show time relationship in simple narrative essays (e.g., *then, this time, etc.*).
- Select the most logical place to add a sentence in a paragraph.
- Use conjunctive adverbs or phrases to express straightforward logical relationships (e.g., *first, afterward, in response*).
- Decide the most logical place to add a sentence in an essay.
- Add a sentence that introduces a simple paragraph.
- Determine the need for conjunctive adverbs or phrases to create subtle logical connections between sentences (e.g., *therefore, however, in addition*).
- Rearrange the sentences in a fairly uncomplicated paragraph for the sake of logic.
- Add a sentence to introduce or conclude the essay or to provide a transition between paragraphs when the essay is fairly straightforward.
- Make sophisticated distinctions concerning the logical use of conjunctive adverbs or phrases, particularly when signaling a shift between paragraphs.
- Rearrange sentences to improve the logic and coherence of a complex paragraph.
- Add a sentence to introduce or conclude a fairly complex paragraph.
- Consider the need for introductory sentences or transitions, basing decisions on a thorough understanding of both the logic and rhetorical effect of the paragraph and essay.

E3 Word Choice in Terms of Style, Tone, Clarity, and Economy

- Revise sentences to correct awkward and confusing arrangements of sentence elements.
- Revise vague nouns and pronouns that create obvious logic problems.
- Delete obviously synonymous and wordy material in a sentence.
- Revise expressions that deviate from the style of an essay.
- Delete redundant material when information is repeated in different parts of speech (e.g., *alarmingly startled*).
- Use the word or phrase most consistent with the style and tone of a fairly straightforward essay.
- Determine the clearest and most logical conjunction to link clauses.
- Revise a phrase that is redundant in terms of the meaning and logic of the entire sentence.
- Identify and correct ambiguous pronoun references.
- Use the word or phrase most appropriate in terms of the content of the sentence and tone of the essay.
- Correct redundant material that involves sophisticated vocabulary and sounds acceptable as conversational English (e.g., *an aesthetic viewpoint* versus *the outlook of an aesthetic viewpoint*).
- Correct vague and wordy or clumsy and confusing writing containing sophisticated language.
- Delete redundant material that involves subtle concepts or that is redundant in terms of the paragraph as a whole.

E4 Sentence Structure and Formation

- Use conjunctions or punctuation to join simple clauses.
- Revise shifts in verb tense between simple clauses in a sentence or between simple adjoining sentences.
- Determine the need for punctuation and conjunctions to avoid awkward sounding sentence fragments and fused sentences.
- Decide the appropriate verb tense and voice by considering the meaning of the entire sentence.
- Recognize and correct marked disturbances of sentence flow and structure (e.g., participial phrase fragments, missing or incorrect relative pronouns, dangling or misplaced modifiers).
- Revise to avoid faulty placement of phrases and faulty coordination and subordination of clauses in sentences with subtle structural problems.
- Maintain consistent verb tense and pronoun person on the basis of the preceding clause or sentence.
- Use sentence-combining techniques, effectively avoiding problematic comma splices, run-on sentences, and sentence fragments, especially in sentences containing compound subjects or verbs.
- Maintain a consistent and logical use of verb tense and pronoun person on the basis of information in the paragraph or essay as a whole.
- Work comfortably with long sentences and complex clausal relationships within sentences, avoiding weak conjunctions between independent clauses and maintaining parallel structure between clauses.

E5 Conventions of Usage

- Solve such basic grammatical problems as how to form the past and past participle of irregular but commonly used verbs and how to form comparative and superlative adjectives.
- Solve such grammatical problems as whether to use an adverb or adjective form, how to ensure straightforward subject–verb and pronoun–antecedent agreement, and which preposition to use in simple contexts.
- Recognize and use the appropriate word in frequently confused pairs such as *there* and *their*, *past* and *passed*, and *led* and *lead*.
- Use idiomatically appropriate prepositions, especially in combination with verbs (e.g., *long for*, *appeal to*).
- Ensure that a verb agrees with its subject when there is some text between the two.
- Ensure that a pronoun agrees with its antecedent when the two occur in separate clauses or sentences.
- Identify the correct past and past participle forms of irregular and infrequently used verbs, and form present–perfect verbs by using *have* rather than *of*.
- Correctly use reflexive pronouns, the possessive pronouns *its* and *your*, and the relative pronouns *who* and *whom*.

- Ensure that a verb agrees with its subject in unusual situations (e.g., when the subject–verb order is inverted or when the subject is an indefinite pronoun).
- Provide idiomatically and contextually appropriate prepositions following verbs in situations involving sophisticated language or ideas.
- Ensure that a verb agrees with its subject when a phrase or clause between the two suggests a different number for the verb.

E6 Conventions of Punctuation

- Delete commas that create basic sense problems (e.g., between verb and direct object).
- Provide appropriate punctuation in straightforward situations (e.g., items in a series).
- Delete commas that disturb the sentence flow (e.g., between modifier and modified element).
- Use commas to set off simple parenthetical phrases.
- Delete unnecessary commas when an incorrect reading of the sentence suggests a pause that should be punctuated (e.g., between verb and direct object clause).
- Use punctuation to set off complex parenthetical phrases.
- Recognize and delete unnecessary commas based on a careful reading of a complicated sentence (e.g., between the elements of a compound subject or compound verb joined by *and*).
- Use apostrophes to indicate simple possessive nouns.
- Recognize inappropriate uses of colons and semicolons.
- Use commas to set off a nonessential/nonrestrictive appositive or clause.
- Deal with multiple punctuation problems (e.g., compound sentences containing unnecessary commas and phrases that may or may not be parenthetical).
- Use an apostrophe to show possession, especially with irregular plural nouns.
- Use a semicolon to indicate a relationship between closely related independent clauses.
- Use a colon to introduce an example or an elaboration.

Math

M1 Basic Operations and Applications

- Perform one-operation computation with whole numbers and decimals.
- Solve problems in one or two steps using whole numbers.
- Perform common conversions (e.g., inches to feet or hours to minutes).
- Solve routine one-step arithmetic problems (using whole numbers, fractions, and decimals) such as single-step percent.
- Solve some routine two-step arithmetic problems.
- Solve routine two-step or three-step arithmetic problems involving concepts such as rate and proportion, tax added, percentage off, and computing with a given average.
- Solve multistep arithmetic problems that involve planning or converting units of measure (e.g., feet per second to miles per hour).
- Solve word problems containing several rates, proportions, or percentages.
- Solve complex arithmetic problems involving percent of increase or decrease and problems requiring integration of several concepts from pre-algebra and/or pre-geometry (e.g., comparing percentages or averages, using several ratios, and finding ratios in geometry settings).

M2 Probability, Statistics, and Data Analysis

- Calculate the average of a list of positive whole numbers.
- Perform a single computation using information from a table or chart.
- Calculate the average of a list of numbers.
- Calculate the average, given the number of data values and the sum of the data values.
- Read tables and graphs.
- Perform computations on data from tables and graphs.

- Use the relationship between the probability of an event and the probability of its complement.
- Calculate the missing data value, given the average and all data values but one.
- Translate from one representation of data to another (e.g., a bar graph to a circle graph).
- Determine the probability of a simple event.
- Exhibit knowledge of simple counting techniques.*
- Calculate the average, given the frequency counts of all the data values.
- Manipulate data from tables and graphs.
- Compute straightforward probabilities for common situations.
- Use Venn diagrams in counting.*
- Calculate or use a weighted average.
- Interpret and use information from figures, tables, and graphs.
- Apply counting techniques.
- Compute a probability when the event and/or sample space is not given or obvious.
- Distinguish between mean, median, and mode for a list of numbers.
- Analyze and draw conclusions based on information from figures, tables, and graphs.
- Exhibit knowledge of conditional and joint probability.

M3 Numbers: Concepts and Properties

- Recognize equivalent fractions and fractions in lowest terms.
- Recognize one-digit factors of a number.
- Identify a digit's place value.
- Exhibit knowledge of elementary number concepts including rounding, the ordering of decimals, pattern identification, absolute value, primes, and greatest common factor.
- Find and use the least common multiple.
- Order fractions.
- Work with numerical factors.
- Work with scientific notation.
- Work with squares and square roots of numbers.
- Work problems involving positive integer exponents.*
- Work with cubes and cube roots of numbers.*
- Determine when an expression is undefined.*
- Exhibit some knowledge of the complex numbers.†
- Apply number properties involving prime factorization.
- Apply number properties involving even and odd numbers and factors and multiples.
- Apply number properties involving positive and negative numbers.
- Apply rules of exponents.
- Multiply two complex numbers.†
- Draw conclusions based on number concepts, algebraic properties, and/or relationships between expressions and numbers.
- Exhibit knowledge of logarithms and geometric sequences.
- Apply properties of complex numbers.

M4 Expressions, Equations, and Inequalities

- Exhibit knowledge of basic expressions (e.g., identify an expression for a total as $b + g$).
- Solve equations in the form $x + a = b$, where a and b are whole numbers or decimals.
- Substitute whole numbers for unknown quantities to evaluate expressions.
- Solve one-step equations having integer or decimal answers.
- Combine like terms (e.g., $2x + 5x$).
- Evaluate algebraic expressions by substituting integers for unknown quantities.
- Add and subtract simple algebraic expressions.
- Solve routine first-degree equations.

- Perform straightforward word-to-symbol translations.
- Multiply two binomials.*
- Solve real-world problems using first-degree equations.
- Write expressions, equations, or inequalities with a single variable for common pre-algebra settings (e.g., rate and distance problems and problems that can be solved by using proportions).
- Identify solutions to simple quadratic equations.
- Add, subtract, and multiply polynomials.*
- Factor simple quadratics (e.g., the difference of squares and perfect square trinomials).*
- Solve first-degree inequalities that do not require reversing the inequality sign.*
- Manipulate expressions and equations.
- Write expressions, equations, and inequalities for common algebra settings.
- Solve linear inequalities that require reversing the inequality sign.
- Solve absolute value equations.
- Solve quadratic equations.
- Find solutions to systems of linear equations.
- Write expressions that require planning and/or manipulating to accurately model a situation.
- Write equations and inequalities that require planning, manipulating, and/or solving.
- Solve simple absolute value inequalities.

M5 Graphical Representations

- Identify the location of a point with a positive coordinate on the number line.
- Locate points on the number line and in the first quadrant.
- Locate points in the coordinate plane.
- Comprehend the concept of length on the number line.*
- Exhibit knowledge of slope.*
- Identify the graph of a linear inequality on the number line.*
- Determine the slope of a line from points or equations.*
- Match linear graphs with their equations.*
- Find the midpoint of a line segment.*
- Interpret and use information from graphs in the coordinate plane.
- Match number line graphs with solution sets of linear inequalities.
- Use the distance formula.
- Use properties of parallel and perpendicular lines to determine an equation of a line or coordinates of a point.
- Recognize special characteristics of parabolas and circles (e.g., the vertex of a parabola and the center or radius of a circle).†
- Match number line graphs with solution sets of simple quadratic inequalities.
- Identify characteristics of graphs based on a set of conditions or on a general equation such as $y = ax^2 + c$.
- Solve problems integrating multiple algebraic and/or geometric concepts.
- Analyze and draw conclusions based on information from graphs in the coordinate plane.

M6 Properties of Plane Figures

- Exhibit some knowledge of the angles associated with parallel lines.
- Find the measure of an angle using properties of parallel lines.
- Exhibit knowledge of basic angle properties and special sums of angle measures (e.g., 90° , 180° , and 360°).
- Use several angle properties to find an unknown angle measure.
- Recognize Pythagorean triples.*
- Use properties of isosceles triangles.*
- Apply properties of 30° - 60° - 90° , 45° - 45° - 90° , similar, and congruent triangles.
- Use the Pythagorean theorem.
- Draw conclusions based on a set of conditions.

- Solve multistep geometry problems that involve integrating concepts, planning, visualization, and/or making connections with other content areas.
- Use relationships among angles, arcs, and distances in a circle.

M7 Measurement

- Estimate or calculate the length of a line segment based on other lengths given on a geometric figure.
- Compute the perimeter of polygons when all side lengths are given.
- Compute the area of rectangles when whole number dimensions are given.
- Compute the area and perimeter of triangles and rectangles in simple problems.
- Use geometric formulas when all necessary information is given.
- Compute the area of triangles and rectangles when one or more additional simple steps are required.
- Compute the area and circumference of circles after identifying necessary information.
- Compute the perimeter of simple composite geometric figures with unknown side lengths.*
- Use relationships involving area, perimeter, and volume of geometric figures to compute another measure.
- Use scale factors to determine the magnitude of a size change.
- Compute the area of composite geometric figures when planning or visualization is required.

M8 Functions

- Evaluate quadratic functions, expressed in function notation, at integer values.
- Evaluate polynomial functions, expressed in function notation, at integer values.†
- Express the sine, cosine, and tangent of an angle in a right triangle as a ratio of given side lengths.†
- Evaluate composite functions at integer values.†
- Apply basic trigonometric ratios to solve right-triangle problems.†
- Write an expression for the composite of two simple functions.†
- Use trigonometric concepts and basic identities to solve problems.†
- Exhibit knowledge of unit circle trigonometry.†
- Match graphs of basic trigonometric functions with their equations.

Notes

- Students who score in the 1–12 range are most likely beginning to develop the knowledge and skills assessed in the other ranges.
- Standards followed by an asterisk (*) apply to the PLAN and ACT Mathematics tests only.
- Standards followed by a dagger (†) apply to the ACT Mathematics test only.

Reading

R1 Main Ideas and Author’s Approach

- Recognize a clear intent of an author or narrator in uncomplicated literary narratives.
- Identify a clear main idea or purpose of straightforward paragraphs in uncomplicated literary narratives.
- Infer the main idea or purpose of straightforward paragraphs in uncomplicated literary narratives.
- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in uncomplicated passages.
- Identify a clear main idea or purpose of any paragraph or paragraphs in uncomplicated passages.
- Infer the main idea or purpose of straightforward paragraphs in more challenging passages.
- Summarize basic events and ideas in more challenging passages.
- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in more challenging passages.
- Infer the main idea or purpose of more challenging passages or their paragraphs.
- Summarize events and ideas in virtually any passage.

- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in virtually any passage.
- Identify clear main ideas or purposes of complex passages or their paragraphs.

R2 Supporting Details

- Locate basic facts (e.g., names, dates, events) clearly stated in a passage.
- Locate simple details at the sentence and paragraph level in uncomplicated passages.
- Recognize a clear function of a part of an uncomplicated passage.
- Locate important details in uncomplicated passages.
- Make simple inferences about how details are used in passages.
- Locate important details in more challenging passages.
- Locate and interpret minor or subtly stated details in uncomplicated passages.
- Discern which details, though they may appear in different sections throughout a passage, support important points in more challenging passages.
- Locate and interpret minor or subtly stated details in more challenging passages.
- Use details from different sections of some complex informational passages to support a specific point or argument.
- Locate and interpret details in complex passages.
- Understand the function of a part of a passage when the function is subtle or complex.

R3 Sequential, Comparative, and Cause–Effect Relationships

- Determine when (e.g., first, last, before, after) or if an event occurred in uncomplicated passages.
- Recognize clear cause–effect relationships described within a single sentence in a passage.
- Identify relationships between main characters in uncomplicated literary narratives.
- Recognize clear cause–effect relationships within a single paragraph in uncomplicated literary narratives.
- Order simple sequences of events in uncomplicated literary narratives.
- Identify clear relationships between people, ideas, and so forth in uncomplicated passages.
- Identify clear cause–effect relationships in uncomplicated passages.
- Order sequences of events in uncomplicated passages.
- Understand relationships between people, ideas, and so forth in uncomplicated passages.
- Identify clear relationships between characters, ideas, and so forth in more challenging literary narratives.
- Understand implied or subtly stated cause–effect relationships in uncomplicated passages.
- Identify clear cause–effect relationships in more challenging passages.
- Order sequences of events in more challenging passages.
- Understand the dynamics between people, ideas, and so forth in more challenging passages.
- Understand implied or subtly stated cause–effect relationships in more challenging passages.
- Order sequences of events in complex passages.
- Understand the subtleties in relationships between people, ideas, and so forth in virtually any passage.
- Understand implied, subtle, or complex cause–effect relationships in virtually any passage.

R4 Meaning of Words

- Understand the implication of a familiar word or phrase and of simple descriptive language.
- Use context to understand basic figurative language.
- Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in uncomplicated passages.
- Use context to determine the appropriate meaning of virtually any word, phrase, or statement in uncomplicated passages.
- Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in more challenging passages.

- Determine the appropriate meaning of words, phrases, or statements from figurative or somewhat technical contexts.
- Determine, even when the language is richly figurative and the vocabulary is difficult, the appropriate meaning of context-dependent words, phrases, or statements in virtually any passage.

R5 Generalizations and Conclusions

- Draw simple generalizations and conclusions about the main characters in uncomplicated literary narratives.
- Draw simple generalizations and conclusions about people, ideas, and so forth in uncomplicated passages.
- Draw generalizations and conclusions about people, ideas, and so forth in uncomplicated passages.
- Draw simple generalizations and conclusions using details that support the main points of more challenging passages.
- Draw subtle generalizations and conclusions about characters, ideas, and so forth in uncomplicated literary narratives.
- Draw generalizations and conclusions about people, ideas, and so forth in more challenging passages.
- Use information from one or more sections of a more challenging passage to draw generalizations and conclusions about people, ideas, and so forth.
- Draw complex or subtle generalizations and conclusions about people, ideas, and so forth, often by synthesizing information from different portions of the passage.
- Understand and generalize about portions of a complex literary narrative.

Science

S1 Interpretation of Data

- Select a single piece of data (numerical or non-numerical) from a simple data presentation (e.g., a table or graph with two or three variables, a food web diagram).
- Identify basic features of a table, graph, or diagram (e.g., headings, units of measurement, axis labels).
- Select two or more pieces of data from a simple data presentation.
- Understand basic scientific terminology.
- Find basic information in a brief body of text.
- Determine how the value of one variable changes as the value of another variable changes in a simple data presentation.
- Select data from a complex data presentation (e.g., a table or graph with more than three variables, a phase diagram).
- Compare or combine data from a simple data presentation (e.g., order or sum data from a table).
- Translate information into a table, graph, or diagram.
- Compare or combine data from two or more simple data presentations (e.g., categorize data from a table using a scale from another table).
- Compare or combine data from a complex data presentation.
- Interpolate between data points in a table or graph.
- Determine how the value of one variable changes as the value of another variable changes in a complex data presentation.
- Identify and/or use a simple (e.g., linear) mathematical relationship between data.
- Analyze given information when presented with new, simple information.
- Compare or combine data from a simple data presentation with data from a complex data presentation.
- Identify and/or use a complex (e.g., nonlinear) mathematical relationship between data.
- Extrapolate from data points in a table or graph.
- Compare or combine data from two or more complex data presentations.
- Analyze given information when presented with new, complex information.

S2 Scientific Investigation

- Understand the methods and tools used in a simple experiment.
- Understand the methods and tools used in a moderately complex experiment.
- Understand a simple experimental design.
- Identify a control in an experiment.
- Identify similarities and differences between experiments.
- Understand the methods and tools used in a complex experiment.
- Understand a complex experimental design.
- Predict the results of an additional trial or measurement in an experiment.
- Determine the experimental conditions that would produce specified results.
- Determine the hypothesis for an experiment.
- Identify an alternate method for testing a hypothesis.
- Understand precision and accuracy issues.
- Predict how modifying the design or methods of an experiment will affect results.
- Identify an additional trial or experiment that could be performed to enhance or evaluate experimental results.

S3 Evaluation of Models, Inferences, and Experimental Results

- Select a simple hypothesis, prediction, or conclusion that is supported by a data presentation or a model.
- Identify key issues or assumptions in a model.
- Select a simple hypothesis, prediction, or conclusion that is supported by two or more data presentations or models.
- Determine whether given information supports or contradicts a simple hypothesis or conclusion and why.
- Identify strengths and weaknesses in one or more models.
- Identify similarities and differences between models.
- Determine which model(s) is/are supported or weakened by new information.
- Select a data presentation or a model that supports or contradicts a hypothesis, prediction, or conclusion.
- Select a complex hypothesis, prediction, or conclusion that is supported by a data presentation or model.
- Determine whether new information supports or weakens a model and why.
- Use new information to make a prediction based on a model.
- Select a complex hypothesis, prediction, or conclusion that is supported by two or more data presentations or models.
- Determine whether given information supports or contradicts a complex hypothesis or conclusion and why.

Writing

W1 Expressing Judgments

- Show a little understanding of the persuasive purpose of the task, but neglect to take or to maintain a position on the issue in the prompt.
- Show limited recognition of the complexity of the issue in the prompt.
- Show a basic understanding of the persuasive purpose of the task by taking a position on the issue in the prompt but may not maintain that position.
- Show a little recognition of the complexity of the issue in the prompt by acknowledging, but only briefly describing, a counterargument to the writer's position.
- Show understanding of the persuasive purpose of the task by taking a position on the issue in the prompt.
- Show some recognition of the complexity of the issue in the prompt by doing the following:
 - Acknowledging counterarguments to the writer's position
 - Providing some response to counterarguments to the writer's position
- Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a broad context for discussion.

- Show recognition of the complexity of the issue in the prompt by doing the following:
 - Partially evaluating implications and/or complications of the issue
 - Posing and partially responding to counterarguments to the writer's position
- Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a critical context for discussion.
- Show understanding of the complexity of the issue in the prompt by doing the following:
 - Examining different perspectives
 - Evaluating implications or complications of the issue
 - Posing and fully discussing counterarguments to the writer's position

W2 Focusing on the Topic

- Maintain a focus on the general topic in the prompt through most of the essay.
- Maintain a focus on the general topic in the prompt throughout the essay.
- Maintain a focus on the general topic in the prompt throughout the essay, and attempt a focus on the specific issue in the prompt.
- Present a thesis that establishes focus on the topic.
- Maintain a focus on discussion of the specific topic and issue in the prompt throughout the essay.
- Present a thesis that establishes a focus on the writer's position on the issue.
- Maintain a clear focus on discussion of the specific topic and issue in the prompt throughout the essay.
- Present a critical thesis that clearly establishes the focus on the writer's position on the issue.

W3 Developing a Position

- Offer a little development, with one or two ideas; if examples are given, they are general and may not be clearly relevant; resort often to merely repeating ideas.
- Show little or no movement between general and specific ideas and examples.
- Offer limited development of ideas using a few general examples; resort sometimes to merely repeating ideas.
- Show little movement between general and specific ideas and examples.
- Develop ideas by using some specific reasons, details, and examples.
- Show some movement between general and specific ideas and examples.
- Develop most ideas fully, using some specific and relevant reasons, details, and examples.
- Show clear movement between general and specific ideas and examples.
- Develop several ideas fully, using specific and relevant reasons, details, and examples.
- Show effective movement between general and specific ideas and examples.

W4 Organizing Ideas

- Provide a discernible organization with some logical grouping of ideas in parts of the essay.
- Use a few simple and obvious transitions.
- Present a discernible, though minimally developed, introduction and conclusion.
- Provide a simple organization with logical grouping of ideas in parts of the essay.
- Use some simple and obvious transitional words, though they may at times be inappropriate or misleading.
- Present a discernible, though underdeveloped, introduction and conclusion.
- Provide an adequate but simple organization with logical grouping of ideas in parts of the essay but with little evidence of logical progression of ideas.
- Use some simple and obvious, but appropriate, transitional words and phrases.
- Present a discernible introduction and conclusion with a little development.
- Provide unity and coherence throughout the essay, sometimes with a logical progression of ideas.
- Use relevant, though at times simple and obvious, transitional words and phrases to convey logical relationships between ideas.
- Present a somewhat developed introduction and conclusion.

- Provide unity and coherence throughout the essay, often with a logical progression of ideas.
- Use relevant transitional words, phrases, and sentences to convey logical relationships between ideas.
- Present a well-developed introduction and conclusion.

W5 Using Language

- Show limited control of language by doing the following:
 - Correctly employing some of the conventions of standard English grammar, usage, and mechanics but with distracting errors that sometimes significantly impede understanding
 - Using simple vocabulary
 - Using simple sentence structure
 - Correctly employing some of the conventions of standard English grammar, usage, and mechanics but with distracting errors that sometimes impede understanding
 - Using simple but appropriate vocabulary
 - Using a little sentence variety, though most sentences are simple in structure
 - Correctly employing many of the conventions of standard English grammar, usage, and mechanics but with some distracting errors that may occasionally impede understanding
 - Using appropriate vocabulary
 - Using some varied kinds of sentence structures to vary pace
 - Correctly employing most conventions of standard English grammar, usage, and mechanics with a few distracting errors but none that impede understanding
 - Using some precise and varied vocabulary
 - Using several kinds of sentence structures to vary pace and to support meaning
 - Correctly employing most conventions of standard English grammar, usage, and mechanics with just a few, if any, errors
 - Using precise and varied vocabulary
 - Using a variety of kinds of sentence structures to vary pace and to support meaning

Appendix E: Pathway Content Standards

AGRICULTURE, FOOD, AND NATURAL RESOURCES (AFNR) PATHWAY CONTENT STANDARDS AND PERFORMANCE ELEMENTS

The AFNR Pathway Content Standards and Performance Elements are adapted from *National Agriculture, Food and Natural Resources (AFNR) Career Cluster Content Standards*. Reprinted with permission from the National Council for Agricultural Education, 1410 King Street, Suite 400, Alexandria, VA 22314. (800) 772-0939. Copyright © 2009. A complete copy of the National Standards can be downloaded from the Team Ag Ed Learning Center at <https://aged.learn.com>.

AGRIBUSINESS SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of principles and techniques for the development and management of agribusiness systems.

- ABS.01. Utilize economic principles to establish and manage an AFNR enterprise.**
 - ABS.01.01. Apply principles of capitalism in the business environment.
 - ABS.01.02. Apply principles of entrepreneurship in businesses.
- ABS.02. Utilize appropriate management planning principles in AFNR business enterprises.**
 - ABS.02.01. Compose and analyze a business plan for an enterprise.
 - ABS.02.02. Read, interpret, evaluate, and write a mission statement to guide business goals, objectives, and resource allocation.
 - ABS.02.03. Apply appropriate management skills to organize a business.
 - ABS.02.04. Recruit, train, and retain appropriate and productive human resources for business.
- ABS.03. Utilize record keeping to accomplish AFNR business objectives while complying with laws and regulations.**
 - ABS.03.01. Prepare and maintain all files needed to accomplish effective record keeping.
 - ABS.03.02. Implement appropriate inventory management practices.
- ABS.04. Apply generally accepted accounting principles and skills to manage cash budgets, credit budgets, and credit for AFNR businesses.**
 - ABS.04.01. Use accounting fundamentals to accomplish dependable bookkeeping and fiscal management.
- ABS.05. Assess accomplishment of goals and objectives by an AFNR business.**
 - ABS.05.01. Maintain and interpret financial information (income statements, balance sheets, inventory, purchase orders, accounts receivable, and cash-flow analyses) for businesses.
- ABS.06. Use industry-accepted marketing practices to accomplish AFNR business objectives.**
 - ABS.06.01. Conduct appropriate market and marketing research.
 - ABS.06.02. Develop a marketing plan.
 - ABS.06.03. Develop strategies for marketing plan implementation.
 - ABS.06.04. Develop specific tactics to market AFNR products and services.
- ABS.07. Create a production system plan.**
 - ABS.07.01. Prepare a step-by-step production plan that identifies needed resources.
 - ABS.07.02. Develop a production and operational plan.
 - ABS.07.03. Utilize appropriate techniques to determine the most likely strengths, weaknesses, and inconsistencies in a business plan, and relate these to risk management strategies.
 - ABS.07.04. Manage risk and uncertainty.

ANIMAL SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles and practices to the production and management of animals.

- AS.01. Examine the components, historical development, global implications, and future trends of the animal systems industry.**
- AS.01.01. Evaluate the development and implications of animal origin, domestication, and distribution.
- AS.02. Classify, evaluate, select, and manage animals based on anatomical and physiological characteristics.**
- AS.02.01. Classify animals according to hierarchical taxonomy and agricultural use.
 - AS.02.02. Apply principles of comparative anatomy and physiology to uses within various animal systems.
 - AS.02.03. Select animals for specific purposes and maximum performance based on anatomy and physiology.
- AS.03. Provide for the proper health care of animals.**
- AS.03.01. Prescribe and implement a prevention and treatment program for animal diseases, parasites, and other disorders.
 - AS.03.02. Provide for the biosecurity of agricultural animals and production facilities.
- AS.04. Apply principles of animal nutrition to ensure the proper growth, development, reproduction, and economic production of animals.**
- AS.04.01. Formulate feed rations to provide for the nutritional needs of animals.
 - AS.04.02. Prescribe and administer animal feed additives and growth promotants in animal production.
- AS.05. Evaluate and select animals based on scientific principles of animal production.**
- AS.05.01. Evaluate the male and female reproductive systems in selecting animals.
 - AS.05.02. Evaluate animals for breeding readiness and soundness.
 - AS.05.03. Apply scientific principles in the selection and breeding of animals.
- AS.06. Prepare and implement animal handling procedures for the safety of animals, producers and consumers of animal products.**
- AS.06.01. Demonstrate safe animal handling and management techniques.
 - AS.06.02. Implement procedures to ensure that animal products are safe.
- AS.07. Select animal facilities and equipment that provide for the safe and efficient production, housing, and handling of animals.**
- AS.07.01. Design animal housing, equipment, and handling facilities for the major systems of animal production.
 - AS.07.02. Comply with government regulations and safety standards for facilities used in animal production.
- AS.08. Analyze environmental factors associated with animal production.**
- AS.08.01. Reduce the effects of animal production on the environment.
 - AS.08.02. Evaluate the effects of environmental conditions on animals.

BIOTECHNOLOGY

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles and techniques to biotechnology in agriculture.

- BS.01. Recognize the historical, social, cultural, and potential applications of biotechnology.**
- BS.01.01. Distinguish major innovators, historical developments, and potential applications of biotechnology in agriculture.
 - BS.01.02. Determine regulatory issues, and identify agencies associated with biotechnology.
 - BS.01.03. Analyze the ethical, legal, social, and cultural issues relating to biotechnology.
- BS.02. Demonstrate laboratory skills as applied to biotechnology.**
- BS.02.01. Maintain and interpret biotechnology laboratory records.
 - BS.02.02. Operate biotechnology laboratory equipment according to standard procedures.
 - BS.02.03. Demonstrate proper laboratory procedures using biological materials.
 - BS.02.04. Safely manage biological materials, chemicals, and wastes used in the laboratory.
 - BS.02.05. Perform microbiology, molecular biology, enzymology, and immunology procedures.
- BS.03. Demonstrate the application of biotechnology to Agriculture, Food, and Natural Resources (AFNR).**
- BS.03.01. Evaluate the application of genetic engineering to improve products of AFNR systems.
 - BS.03.02. Perform biotechnology processes used in AFNR systems.
 - BS.03.03. Use biotechnology to monitor and evaluate procedures performed in AFNR systems.

ENVIRONMENTAL SERVICE SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles and techniques to the management of environmental service systems.

- ESS.01. Use analytical procedures to plan and evaluate environmental service systems.**
- ESS.01.01. Analyze and interpret samples.
- ESS.02. Assess the impact of policies and regulations on environmental service systems.**
- ESS.02.01. Interpret laws affecting environmental service systems.
- ESS.03. Apply scientific principles to environmental service systems.**
- ESS.03.01. Apply meteorology principles to environmental service systems.
 - ESS.03.02. Apply soil science principles to environmental service systems.
 - ESS.03.03. Apply hydrology principles to environmental service systems.
 - ESS.03.04. Apply best management techniques associated with the properties, classifications, and functions of wetlands.
 - ESS.03.05. Apply chemistry principles to environmental service systems.
 - ESS.03.06. Apply microbiology principles to environmental service systems.
- ESS.04. Operate environmental service systems to manage a facility environment.**
- ESS.04.01. Use pollution control measures to maintain a safe facility environment.
 - ESS.04.02. Manage safe disposal of all categories of solid waste.
 - ESS.04.03. Apply the principles of public drinking water treatment operations to ensure safe water at a facility.
 - ESS.04.04. Apply principles of wastewater treatment to manage wastewater disposal in keeping with rules and regulations.
 - ESS.04.05. Manage hazardous materials to assure a safe facility and to comply with applicable regulations.

- ESS.05. Examine the relationships between energy sources and environmental service systems.**
ESS.05.01. Compare and contrast the impact of conventional and alternative energy sources on the environment.
- ESS.06. Use tools, equipment, machinery, and technology to accomplish tasks in environmental service systems.**
ESS.06.01. Use technological and mathematical tools to map land, facilities, and infrastructure.
ESS.06.02. Maintain tools, equipment, and machinery in safe working order for tasks in environmental service systems.

FOOD PRODUCTS AND PROCESSING SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles, practices, and techniques in the processing, storage, and development of food products.

- FPP.01. Examine components of the food industry and historical development of food products and processing.**
FPP.01.01. Evaluate the significance and implications of changes and trends in the food products and processing industry.
FPP.01.02. Work effectively with industry organizations, groups, and regulatory agencies affecting the food products and processing industry.
- FPP.02. Apply safety principles, recommended equipment, and facility management techniques to the food products and processing industry.**
FPP.02.01. Manage operational procedures, and create equipment and facility maintenance plans.
FPP.02.02. Implement Hazard Analysis and Critical Control Point (HACCP) procedures to establish operating parameters.
FPP.02.03. Apply safety and sanitation procedures in the handling, processing, and storing of food products.
FPP.02.04. Demonstrate worker safety procedures with food product and processing equipment and facilities.
- FPP.03. Apply principles of science to the food products and processing industry.**
FPP.03.01. Apply principles of science to food processing to provide a safe, wholesome, and nutritious food supply.
- FPP.04. Select and process food products for storage, distribution, and consumption.**
FPP.04.01. Utilize harvesting, selection, and inspection techniques to obtain quality food products for processing.
FPP.04.02. Evaluate, grade, and classify processed food products.
FPP.04.03. Process, preserve, package, and present food and food products for sale and distribution.

NATURAL RESOURCE SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles and techniques to the management of natural resources.

- NRS.01. Explain interrelationships between natural resources and humans necessary to conduct management activities in natural environments.**
NRS.01.01. Apply knowledge of natural resource components to the management of natural resource systems.

- NRS01.02. Classify natural resources.
- NRS.02. Apply scientific principles to natural resource management activities.**
- NRS.02.01. Develop a safety plan for work with natural resources.
- NRS.02.02. Demonstrate cartographic skills to aid in developing, implementing, and evaluating natural resource management plans.
- NRS.02.03. Measure and survey natural resource status to obtain planning data.
- NRS.02.04. Demonstrate natural resource enhancement techniques.
- NRS.02.05. Interpret laws related to natural resource management and protection.
- NRS.02.06. Apply ecological concepts and principles to natural resource systems.
- NRS.03. Apply knowledge of natural resources to production and processing industries.**
- NRS.03.01. Produce, harvest, process, and use natural resource products.
- NRS.04. Demonstrate techniques used to protect natural resources.**
- NRS.04.01. Manage fires in natural resource systems.
- NRS.04.02. Diagnose plant and wildlife diseases, and follow protocol to prevent their spread.
- NRS.04.03. Manage insect infestations of natural resources.
- NRS.05. Use effective methods and venues to communicate natural resource processes to the public.**
- NRS.05.01. Communicate natural resource information to the public.

PLANT SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of scientific principles and techniques to the production and management of plants.

- PS.01. Apply knowledge of plant classification, plant anatomy, and plant physiology to the production and management of plants.**
- PS.01.01. Classify agricultural plants according to taxonomy systems.
- PS.01.02. Apply knowledge of plant anatomy and the functions of plant structures to activities associated with plant systems.
- PS.01.03. Apply knowledge of plant physiology and energy conversion to plant systems.
- PS.02. Prepare and implement a plant management plan that addresses the influence of environmental factors, nutrients, and soil on plant growth.**
- PS.02.01. Determine the influence of environmental factors on plant growth.
- PS.02.02. Prepare growing media for use in plant systems.
- PS.02.03. Develop and implement a fertilization plan for specific plants or crops.
- PS.03. Propagate, culture, and harvest plants.**
- PS.03.01. Demonstrate plant propagation techniques.
- PS.03.02. Develop and implement a plant management plan for crop production.
- PS.03.03. Develop and implement a plan for integrated pest management.
- PS.03.04. Apply principles and practices of sustainable agriculture to plant production.
- PS.03.05. Harvest, handle, and store crops.
- PS.04. Employ elements of design to enhance an environment.**
- PS.04.01. Create designs using plants.

POWER, STRUCTURAL AND TECHNICAL SYSTEMS

Pathway Content Standard: The student will demonstrate competence in the application of principles and techniques for the development and management of power, structural, and technical systems.

- PST.01. Use physical science principles and engineering applications with power, structural, and technical systems to solve problems and improve performance.**
- PST.01.01. Select energy sources in power generation appropriate to the situation.
 - PST.01.02. Apply physical science laws and principles to identify, classify, and use lubricants.
 - PST.01.03. Identify and use hand and power tools and equipment for service, construction, and fabrication.
- PST.02. Design, operate, and maintain mechanical equipment, structures, biological systems, land treatment, power, and technology.**
- PST.02.01. Perform service routines to maintain power units and equipment.
 - PST.02.02. Operate, service, and diagnose the condition of power units and equipment.
- PST.03. Service and repair mechanical equipment and power systems.**
- PST.03.01. Troubleshoot and repair internal combustion engines.
 - PST.03.02. Utilize manufacturers' guidelines to service and repair the power transmission systems of equipment.
 - PST.03.03. Service and repair hydraulic and pneumatic systems.
 - PST.03.04. Troubleshoot and service electrical systems.
 - PST.03.05. Service vehicle heating and air-conditioning systems.
 - PST.03.06. Service and repair steering, suspension, traction, and vehicle performance systems.
- PST.04. Plan, build and maintain agricultural structures.**
- PST.04.01. Create sketches and plans of agricultural structures.
 - PST.04.02. Apply structural plans, specifications, and building codes.
 - PST.04.03. Examine structural requirements for materials and procedures, and estimate construction cost.
 - PST.04.05. Follow architectural and mechanical plans to construct and/or repair equipment, buildings, and facilities.
- PST.05. Apply technology principles in the use of agricultural technical systems.**
- PST.05.01. Use instruments and meters to test and monitor electrical and electronic processes.
 - PST.05.02. Prepare and/or use electrical drawings to design, install, and troubleshoot control systems.
 - PST.05.03. Use geospatial technologies in agricultural applications.

Appendix F:

National Educational Technology Standards for Students

- T1 Creativity and Innovation
- T2 Communication and Collaboration
- T3 Research and Information Fluency
- T4 Critical Thinking, Problem Solving, and Decision Making
- T5 Digital Citizenship
- T6 Technology Operations and Concepts

T1 Creativity and Innovation

Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students do the following:

- a. Apply existing knowledge to generate new ideas, products, or processes.
- b. Create original works as a means of personal or group expression.
- c. Use models and simulations to explore complex systems and issues.
- d. Identify trends and forecast possibilities.

T2 Communication and Collaboration

Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students do the following:

- a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.
- b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
- c. Develop cultural understanding and global awareness by engaging with learners of other cultures.
- d. Contribute to project teams to produce original works or solve problems.

T3 Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information. Students do the following:

- a. Plan strategies to guide inquiry.
- b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
- c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
- d. Process data and report results.

T4 Critical Thinking, Problem Solving, and Decision Making

Students use critical-thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students do the following:

- a. Identify and define authentic problems and significant questions for investigation.
- b. Plan and manage activities to develop a solution or complete a project.
- c. Collect and analyze data to identify solutions and/or make informed decisions.
- d. Use multiple processes and diverse perspectives to explore alternative solutions.

T5 Digital Citizenship

Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students do the following:

- a. Advocate and practice safe, legal, and responsible use of information and technology.
- b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.

- c. Demonstrate personal responsibility for lifelong learning.
- d. Exhibit leadership for digital citizenship.

T6 Technology Operations and Concepts

Students demonstrate a sound understanding of technology concepts, systems, and operations. Students do the following:

- a. Understand and use technology systems.
- b. Select and use applications effectively and productively.
- c. Troubleshoot systems and applications.
- d. Transfer current knowledge to learning of new technologies.